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PREFACE

The present volume on *Human Behavior* is a natural outgrowth of my *General Psychology.* The more I have studied and reflected upon the problems of human nature, the more I have become convinced that the approach to these problems in terms of consciousness is invalid. The student of mind either assumes mysterious elements which cannot be verified by science, or else he calls the inner and outer environments psychic processes. No one denies that the world is composed of colors, tones, stones, trees, and other similar objects; but no one has shown either that these objects are psychic processes or that the understanding of human nature would be advanced through their analysis. Such sciences as physics, chemistry, and biology are quite competent to describe and explain man's environment. Human nature can best be understood when it is made the direct object of study, and not when it is approached through the medium of the analysis of the world into tastes, smells, colors, pressures, and configurations.

The present discussion is written from what is generally called the behavioristic point of view, which I prefer to call the viewpoint of anthroponomy, the science of human behavior. I have not felt it necessary to neglect many of the numerous contributions which the psychologists have made to the understanding of behavior, although the limitations of size in the present book have restricted the selections which might be utilized. If I have gone too far in accepting such material, this will be compensated for to the extent that students are led to see that *all* of the aspects of human nature are open to a common-sense, non-philosophical solution. The great difficulty with the student of "experience" is that he insists in formulating his problems and conclusions in terms of consciousness, whereas his methods and results always concern behavior and the conditions that determine behavior.

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WALTER S. HUNTER

WORCESTER, MASSACHUSETTS
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TABLE OF CONTENTS

PART I. FIELDS OF ANTHROPONOMY

INTRODUCTION

Anthroponomy and Psychology.—The study of the facts and laws of human behavior may best be designated by the term "anthroponomy," which is derived from the two Greek words *anthropos* (man) and *nomus* (law). This term is to be contrasted with the more widely current one, "psychology," which suggests that the chief subject matter for study in the science of human nature is the psyche. The term "anthroponomy" has the great advantage of indicating directly that man himself is the central problem for study. The nature and existence of psychic phenomena are problems indissolubly tied up with philosophical speculation. Even such terms as "mind," "mental," and "experience" have been so closely related to the psychic that they too derive their meanings from philosophical theories. Inasmuch as science is greatly handicapped when it is forced to make use of terms which lead inevitably to philosophical controversy, when its chief concern is really with observable facts, we shall avoid as far as possible all such terms.

The problems of behavior have been extensively studied by psychologists and biologists for many years, but only recently has a vigorous and widespread attempt been made to divorce the study from all entangling alliances with the philosophical assumptions that all behavior may have some relationship to "mind," and that behavior is to be interpreted as an expression of "mental life," or at least as its invariable accompaniment. The beginning of the scientific study of human behavior may be approximately placed in 1830. In Germany during the years following this date work was begun by physiologists and physicists, Ernst Weber, Theodor Fechner, Hermann von Helmholtz, Ewald Hering, and Wilhelm Wundt. The chief problems attacked by these men were in the field of receptor processes. We shall have occasion later in our study to describe some of their work. In France the emphasis was

upon the study of abnormal behavior, as revealed, e.g., in hysteria, hypnosis, and arrested and retarded development. The typical investigators were J. M. Charcot, Pierre Janet, and Alfred Binet. In England we find yet another type of work in the biological studies of Charles Darwin, Herbert Spencer, G. J. Romanes, Lloyd Morgan, and others. These studies developed under the influence of the theory of evolution and were particularly concerned with relating animal and human intelligent behavior. The first laboratory for the study of behavior, under the title of psychology, was founded by Wundt at the University of Leipzig in 1874. The first laboratory work in America was inauguarated by William James at Harvard University in 1874–75, to be followed in 1883 by a laboratory established by G. Stanley Hall at the Johns Hopkins University. The greatest incentives in the development of an organized science of behavior have come from the work upon infrahuman behavior and from the studies of behavior tests. This latter work owes its origin to men like Francis Galton in England, James McKeen Cattell in America, and Alfred Binet in France. Laboratory investigations of the behavior of the higher animals was initiated in America by Edward Lee Thorndike. John B. Watson, in particular, has championed the view, termed "behaviorism," that all behavior is to be studied directly and for itself without any implications of the psychic. It is for this behavioristic psychology that we use the name anthroponomy.

The Subject Matter of the Science.—The subject matter of anthroponomy is behavior. By *behavior* is meant *the muscular and glandular activity of the organism,* such, for example, as is present in fear, in walking, in speaking, etc. Not only do anthroponomists study behavior which is readily observable, as we have just indicated, but they also study the more obscure responses found in circulation, respiration, and in changes in blood content. Mention should also be made of the important behavior studied in relation to emotions, e.g., the activity of the glands of internal secretion, and in relation to hunger, e.g., the contractions of the stomach muscles, and of the nature of the neural processes which control

all of them. In the study of these topics anthroponomy comes in the closest possible relation to physiology, zoölogy, and neurology, just as it comes into close relationship with physics in the study of behavior controlled by light and sound. The relation of the science of human behavior to these other sciences will be discussed later in this chapter.

As a matter of experimental convenience, and often of necessity, most of the work on behavior utilizes relatively gross and obvious stimuli which can be applied to definite sense-organs, receptors. In the same manner, the behavior which is observed is usually the obvious changes in the activity of the muscles of speech, of the hands, the legs, and other readily observable portions of the body. We are still in great ignorance of what processes go on in the organism between the receptors, to which the stimuli are applied, and the muscles and glands, the effectors, where the behavior is manifested. We do know, however, that between the receptors and the effectors there exists a very important system of nervous connections. This nervous tissue serves to conduct energy from the receptors to the effectors, which are then thrown into activity. It also serves to co-ordinate the activities occurring in various portions of the body. Much of the explanation of behavior must be sought in the condition of the nervous system at the time a given response is made. This condition of the nervous system is partly the result of the past history of the organism and partly the result of stimuli now acting upon the receptors. All behavior is a result of the total series of stimuli (or of a large proportion of them) acting upon the organism at any one time plus the influence of those modifications of the organism which are either a result of heredity or training. We shall have occasion later (page 179) to point out many of the detailed ways in which behavior is determined. At the present time we are chiefly concerned with pointing out in general that students of behavior study not only stimuli and responses, but that they study all other conditions which control, and thereby explain, the behavior which an animal manifests.

Methods of Studying Behavior.—The goal of anthroponomy is the description and explanation of human behavior. Fortunately many forms of behavior can be produced in the laboratory where they may be observed and also where variations may be produced under carefully determined conditions. There is no particular difficulty in the way of experimental studies of the various problems of receptor sensitivity, of such problems, e.g., as how faint can a stimulus be and still arouse behavior. Nor is there any particular difficulty in studying many of the problems of learning and instinct under the careful conditions of laboratory experimentation. There are other phases of human nature, however, which either cannot be produced experimentally or which considerations of social welfare forbid the scientist to produce experimentally. Genuine and profound emotional disturbances it is unwise to attempt to produce solely for purposes of control and analysis. The retarded development of behavior, various customs, mobs, and the effects of heredity are a few examples of the forms and conditions of behavior which the scientist can only observe as they occur. In these cases he cannot be an experimentalist. He cannot produce and control the phenomena which are to be studied. He can only wait for favorable opportunities for study to present themselves; or, if the material for investigation is defective human nature, he can describe the phenomenon carefully and observe the influence of such factors as education upon it, but he is forbidden to produce the defective material itself. These socially wise limitations constitute a very real handicap to the advance of knowledge concerning the most fundamental aspects of human nature. However, the student of anthroponomy is not alone in thus lacking experimental access to some of his most important problems. The sociologist, the geologist, and the astronomer must also be content to observe the phenomena which they study as occasion permits and to forego an experimental attack upon many problems.

There are three methods of gathering data on human behavior: field observation, clinical observation, and experiment. Concerning the method of experiment little need be said. The principle of ex-

periment is the same in all sciences, and involves the artificial control and repetition of conditions for the accurate analysis and description of phenomena (we shall revert to the topic of experiment again on page 338 in our discussion of *efficient thinking*).

Experimental methods are employed most widely in normal human adult, individual, and phylogenetic anthroponomy. They are being introduced on a small scale in the fields of abnormal and social anthroponomy. In contrast to the controlled and quantitative character of these methods stand the uncontrolled and qualitative procedures of field and clinical observation. Field observation is a term borrowed from biology to designate the method of observation of subjects free in their natural habitat and undisturbed by experimental interference. In biology the method is best exemplified in studies of homing, migration, reproduction, feeding, and other similar activities; in other words, in the great field of habits and instincts as studied by the naturalist. These studies have great value partly in their suggestiveness of specific problems and controls for experimental analysis and partly in the historical, sympathetic, and cultural view which they afford of the animals concerned. In anthroponomy this method of field observation, with the same values and defects, is also employed in the compilation of case histories in individual and abnormal anthroponomy. Clinical observation, although non-experimental and qualitative, differs from field observation in the following fundamental ways. (1) The subject is removed during observation from his natural habitat to special surroundings in which the observer is a dominant factor. (2) Through direct observation of the subject's behavior and through observation aided by measurement, the observer seeks a diagnosis of the subject's relative status of personality. (3) Because of the comparative point of view and the insistent need to evaluate the subject's behavior, clinical observation is less objective and is more open to the influence of prepossession than is field observation. This defect, it should be noted, extends beyond the fields of individual and abnormal anthroponomy wherever the method of personal interview, unaided by objective standards, is

found. And (4) the method of clinical observation is typically an individual method of observation. In conclusion it should be pointed out that clinical observation accompanies much experimental work and furnishes a qualitative record of the subject's attitude and peculiarities of response. The typically qualitative character of the data gathered by field and clinical methods is undoubtedly largely responsible for the shortcomings of the fields concerned in the development of fundamental contributions to the classificatory concepts of anthroponomy.

As we have said, where the student of behavior conducts experiments he always works by a controlled method of stimulus and response. Certain stimuli are applied to the animal, and the correlated changes in behavior are noted. These changes in behavior which follow stimulation leave the organism modified more or less permanently, so that a reapplication of the same stimulus under otherwise equivalent conditions results in new behavior. The behaviorist has studied so many forms of behavior under so many different conditions that he is warranted in believing that *behavior results only from present stimuli and from the retained effects of previous behavior plus whatever influence hereditary conditions may exercise.*

The general method of stimulus and response is used in several specific forms, depending upon the type of behavior aroused. Behavior may be either verbal or non-verbal. Non-verbal behavior is represented in such activities as walking, sleeping, eating, tracing a maze, and solving mechanical puzzles. Verbal behavior includes all talking, writing, and sign language. It may be divided into the two groups of the vocal-verbal and the manual-verbal. The present introduction is not the place to elaborate the nature of these verbal responses. We shall have occasion later (page 327) to discuss them in some detail. Verbal behavior is of particular significance, not only because it is characteristic of man, but because it affords an economical and convenient method of analyzing human behavior. The relatively cumbersome methods used in the study of infrahuman behavior can often be replaced in man with these verbal

response methods with a great saving in time and energy. There is little reason to believe that the verbal methods possess any particular advantage other than this. We have no evidence, e.g., that they are more delicate and sensitive than the non-verbal methods. On the other hand, we know that the verbal responses have a peculiarly complex and uncertain history in each individual's lifetime, and that it is often extremely hazardous to attempt to evaluate results secured only by these methods. It is difficult to decide whether this ambiguity and uncertainty of the verbal responses outweighs the advantage derived from the greater economy of the method or not. In general, the use of non-verbal methods is to be counseled wherever possible until behaviorists are better able to evaluate the verbal methods.

The Basis for Scientific Conclusions.—One of the fundamental tenets of science is that the conclusions drawn from an experiment should not go beyond the results secured. Every experiment involves a problem for solution. The investigator devises a method and an apparatus which he believes will give results bearing upon this problem. When the work is done, the conclusions which are drawn must not only be based upon the results secured, but they must refer to the actual problem which has been studied by means of the method adopted. This problem may or may not be the problem originally chosen for study. Let us illustrate. The problem for study, we shall assume, is the behavior of the muscles of the iris of the eye when light of varying intensities affects the retina. We shall use an instrument to measure the diameter of the pupil of the eye and thus to record indirectly the activity of the iris. For a stimulus we shall use an electric light whose intensity can be varied and measured. Under these conditions of experimentation we secure certain results. From these results it is possible to conclude that the iris muscles so respond that the diameter of the pupil decreases with an increased intensity of light. If now the method and apparatus had been the same, but if we had planned to study "psychic" processes in the subject, obviously the only conclusion which we could have drawn would have been the conclusion

which we did draw, for the method and apparatus used had no relation to "psychic" processes. *Problems for investigation are actually determined by the methods and apparatus used, rather than by the initial formulations of the experimenter.* All experimentation upon man involves the presentation of certain stimuli, such as light, sound, and words, and the recording of the resulting behavior. The conclusions to be drawn are, therefore, that the subject responds in such and such a way when stimulated in the manner described. This is the fundamental method of anthroponomy. As in all science, inferences are made which go beyond the experimental facts, but such inferences are valid only if they are subject to later experimental testing. A hypothesis which lies beyond the realm of possible experimental verification has no scientific standing.

Methods of Explanation.—A few words should be said concerning the explanatory methods of anthroponomy. Explanation seeks to give the determining conditions for whatever phenomenon is under consideration. It always falls short of completeness, and it never pretends to be ultimate. The choice between the more and the less nearly ultimate is one to be made upon the basis of practicality conceived in terms of control and verification by the experimenter. There is, therefore, no one kind of explanation which can be called *the* method of explanation in anthroponomy. In general three types of explanation are available: explanation by analysis into component parts, by formulation of the genetic conditions, and by reference to receptor-conductor-effector mechanisms.

These three types are not always equally practicable. Where they are, the third method of explanation in terms of the individual's action-system is the most nearly ultimate. As the progress of science makes possible a physico-chemical explanation of receptor-conductor-effector activities, it is to be expected that this additional type of explanation will be employed, as is indeed even now the case in many physiological studies. We may illustrate the problem of explanation as it arises in anthroponomy as follows. The verbal response "box" following upon visual stimulation may be explained: (1) by an analysis of the response into its component elements

through the analysis of the sound waves produced or by the registration of tongue and laryngeal movements; (2) by a statement of the number of trials, the total time, etc., of the learning process which was necessary in order that the behavior might occur; and (3) by a statement of the receptor activities which initiated the neural impulse, of the synaptic conditions present, and of the resulting effector activities. It is rarely possible at the present stage of neurological knowledge to make the third type of explanation anything other than suggestive when it is applied even to moderately complex behavior. This form of explanation, however, is approximated by stating the natures of the stimulus and the response and by filling in the neurological data largely by armchair methods. If we change our illustration from that of a verbal response to that of a custom, the third type of explanation may at once be ruled out as an actual method now employed. The explanations attempted of custom are in terms of analysis into component responses and in terms of genesis. This is also true of the explanations offered for many other phenomena, e.g., pathological personalities. Perhaps the most prevalent form of the explanatory question in the science of anthroponomy is this: what are the historical conditions of the behavior in question? We wish to stress the point that anthroponomical explanations are largely genetic, involving to a very large extent—as they do—accounts of the previous training of the subject as well as attempted descriptions of inherited probabilities of response. To this genetic explanation of a given phenomenon, neurological data are added where they are available.

Relation to Other Sciences.—We shall be greatly aided in our understanding of the nature and scope of anthroponomy if we compare it with related disciplines. We shall thus be led to see that anthroponomy is set off from other disciplines, not by a principle (such as the limits of consciousness), but by a content historically and practically determined. First let us consider sociology and education, which are related to anthroponomy in much the same way that this science is related to biology. We must first insist that the chief differences between the fields are to be arrived at

through an examination of the activities of the investigators belonging to each, rather than through an analysis of the terms employed. From the standpoint of philology, e.g., biology may be made to include all of the studies of living organisms. But from the standpoint of what the biologists are actually doing the picture is quite different and will be sketched below. Sociologists, to return to our immediate problem, are concerned with field observations of human social behavior. The procedures employed are as scientific and as thorough as are those found in economics and history, but there is the barest minimum of experimental analysis. Rather, the empirical data are gathered by observational methods. So far as an explanation of social behavior is sought in terms of the fundamental characteristics of human nature, sociology depends upon anthroponomy. Sociologists, therefore, make much use of such factors as instinct, imitation, the self, and thinking in attempting to explain social phenomena; but few if any sociologists are directly concerned with increasing the precision of these fundamental categories.

The discipline of education is a broad field of theory, history, art, science, and administration. It overlaps anthroponomy in the scientific study of human nature under schoolroom conditions and in the study of the rating problems which arise in training in the school subjects. This latter field is well developed under the title of educational tests and measurements, and it is historically and actually closely related in method to the fields of individual and industrial anthroponomy. The former field is as yet less clearly defined. Having been dominated by normal adult anthroponomy, it has hardly begun to attack its problems upon an independent basis. It still depends upon borrowing data gathered under laboratory conditions in anthroponomy, and it is insufficiently concerned with the impossibility of generalizing such data beyond the experimental conditions under which they were obtained. The treatment of the learning process is the most glaring example. Practically none of the data gathered by psychologists and anthroponomists is immediately applicable to the school system. Methods of learn-

ing which are most efficient under controlled laboratory conditions may very well fail to show this high value under the hurly-burly of schoolroom teaching and administration. *Most of these short-comings would be overcome by treating the science of education as a branch of personnel management.* In this case the educator could feel free to attempt the solution of his own special problems unencumbered by efforts to *apply* some other science. Finally, educational theory, so far as it deals with the scientific and not with the philosophic, turns to anthroponomy and biology for its fundamental conceptions.

We are particularly interested in the relationship existing between anthroponomy and biology because many critics have said that to eliminate consciousness from psychology is to turn the study of human nature over to the biologist. Let us analyze the problem and see what conclusion is to be drawn. Biologists turn to physics and chemistry for certain of their more fundamental explanatory formulations, although most biological phenomena cannot as yet be advantageously handled in this fashion and must be referred to proximate sources. Anthroponomy draws many of its explanatory rubrics from biology, and may, therefore, ultimately secure them from physics and chemistry. As yet, however, not only does it not go so far afield, but the great majority of its explanations are evolved from its own domain rather than from the processes studied by the biologist. In addition to this contact with biology there is a great similarity in the general character of the phenomena studied in the two sciences. This similarity we shall proceed to develop.

Biology may be subdivided into a plant and an animal science. Animal biology concerns man and the animals below him. Human biology is most specifically organized in the medical sciences with their underlying pure sciences of human anatomy, embryology, histology and physiology. Outside of the medical field and the before-noted closely related human sciences, animal biology is primarily working with the animals below man, where the human entanglements are genuine but secondary. The field of animal biology

is concerned with structure and behavior. These two problems shade one into the other and still represent a difference in emphasis which is justified by practical interest and by experimental returns. Structure and behavior may be approached from the standpoint of the adult organism or from that of ontogenesis and phylogenesis. In the latter case (phylogenesis) the science of genetics appears; dealing unfortunately at present with the genetics of structures to the practical neglect of the genetics of behavior. Human biology takes little account of the problems of the ontogenesis of behavior except in so far as this behavior concerns disease possibilities at various ages. Where the human biologist gathers data upon behavior as it occurs in infants, children, and adults, he does this definitely under the guidance of medical problems and possibilities, and accordingly he neglects (1) the behavior which is directly involved in the adjustment of the individual to his environment, and (2) the co-ordination of the data gathered from the standpoint of development. He thus leaves his material in a form suited to support and further the diagnosis and treatment of disorders rather than in a form suited to the illumination of the problems of human nature. The studies of the human biologist take account (1) of the structure and structual relationships of the receptor and effector organs involved in behavior, (2) of the nature of the stimuli concerned, and (3) of the detailed quantitative and qualitative aspects of the response. Not all stimulus-response situations, however, are studied. Those selected concern either the stimulus-response possibilities of a single specific apparatus, such as the eye, the ear, the tongue, the biceps muscles, etc., or the stimulus-response conditions within the organism involved in such activities as circulation, digestion, endocrine secretion, etc. The field of human biology has not interested itself to any appreciable extent in the adjustment of the human organism to its external social and non-social environment, and, with the exception of psychiatry and some minor aspects of physiology, it has remained aloof from the language processes. Even the animal biologists have quite generally avoided the problems of learning.

As human biology is set apart from the sciences of physics, chemistry, and bio-chemistry, not by a difference in principles and points of view, but by historically determined differences in subject matter, so human biology is set apart from anthroponomy. Inasmuch as the other sciences are not sharply separated one from the other, it is to be expected that anthroponomy will be intimately related to its fellows. There is no general principle which sets off anthroponomical data from physiological data. Natural phenomena form a continuous series which is subdivided among the sciences by the processes of historical development working upon practical differences in subject matter. We thus find anthroponomy dealing with those phases of human behavior which appeal to investigators as significant and which are not monopolized by other sciences. However, the field is not therefore one of odds and ends, any more than are the fields of zoölogy, physiology, and anthropology, which develop upon an equally practical and non-philological basis. For example, anthroponomy and physiology are both deeply interested in receptor processes. As a result, that problem is under constant investigation in one or the other field; but the relative proportion of anthroponomists and physiologists engaged thereon is constantly shifting. At the present time industrial organizations, whose point of view is essentially that of physics and engineering, are much interested in vision and are perhaps doing the most work upon that process. To the extent that this is true, to that extent is the topic losing connection with anthroponomy and physiology. If the problems of learning, thinking, intelligence, custom, multiple personality, and others seem to be the inviolable property of the anthroponomist, it is only because historical conditions have not first led the human biologist seriously to extend his field to include these topics. Historically considered, subdivisions of labor have promised better results, although it should be added that the general scientific acceptance of a human psyche as involved in the foregoing problems has tended to make many investigators avoid the field. In contrast to the foregoing problems, those of reflex action,

instinct, emotion, receptor processes, reaction time, neural processes, crowd behavior, and others have seriously intrigued sciences other than anthroponomy. The problems have become, in the main, however, primarily anthroponomical in kind because of their more persistent attack from within this field. The broad aspects of natural phenomena are of such self-evident importance for scientific study that to the extent that one group of investigators deserts a given field, to that extent may another group be expected to take over the problem. And so one finds in a historical survey of any particular science contributions made by groups who are no longer represented in the field. This is significantly the case in anthroponomy, where the development of specialists to attack the problems of human nature and thus to free other men from the inner necessity of attempting it is still an urgent necessity.

It is often said by psychologists that the students of behavior, anthroponomists, fail to take account of consciousness in their studies. They say that the behaviorist must be conscious in order to observe behavior. It may be possible to describe the behavior of a subject, as he responds to stimuli, without assuming that mysterious thing called consciousness, but the experimenter must be conscious of that which he observes. The answer to such an argument is this: The only relationship between the experimenter and the behavior which he is observing is one of stimulus and response. The experimenter is stimulated by the subject who is behaving and often by the stimulus which causes the subject to behave. To this stimulation the experimenter responds by writing or talking. What he says or writes is the result of the experiment, the subject matter for the science. If we add another experimenter who is to observe both the subject's behavior and the behavior of the first experimenter, no mysterious element enters. The second experimenter is stimulated by the subject's behavior, by the stimulus which arouses that behavior, and by the behavior of the first experimenter. In response to this stimulation, the second experimenter makes certain verbal responses. The search for that consciousness, which the psy-

chologist says is required in any observation, leads us to an infinite regress. In our descriptions of behavior we shall have little or nothing to say with reference to the relationship between the experimenter and the behavior which he is recording. We do not avoid the subject because there is a mysterious element here but because no new facts or principles of behavior are involved in the relationship.

If, then, there is no principle, such as the presence or absence of consciousness suggested by the psychologists, which divides anthroponomy from the other sciences, what are the fundamental problems which make up the science of human nature and which are not studied, or not intensively studied, in the other fields? The problems which are most characteristically anthroponomical are as follows. (1) *The ontogenesis and use of forms of behavior.* This includes such great topics as learning, thinking, memory, and work. (2) *Those stimulus-response situations which condition language responses.* It is here that the psychologists have busied themselves with psychic processes and introspection. (3) *The analysis of behavior samples with a view to the prediction of general and special performance.* This is the problem developed in the field of tests. And (4) *problems of interstimulation and response.* In contrast to these groups of problems, those of unlearned forms of response (reflex action, instinct, and emotion), of receptor processes, and of neural mechanism, while of immense importance in anthroponomy, are nevertheless problems to whose solution significant contributions have been made and will continue to be made from outside the field of that particular science.

The Fields of Anthroponomy.—It is customary to classify the problems of human nature into certain related groups termed the fields of anthroponomy. Such a classification is arbitrary, but it does serve a useful purpose in the organization of the science. In the present book we shall discuss the following general fields: (1) Phylogenetic behavior, *phylogenetic anthroponomy,* which seeks to relate the behavior of man to that of infrahuman animals. This is

the field most widely known as that of animal behavior. (2) *Individual and applied anthroponomy,* in which the chief problems concern (*a*) the application of behavior methods to the study of business, industry, and education, and (*b*) the analysis of individual differences in ability. This latter phase of the field includes the extensive work done on behavior tests of general intelligence and of such special abilities as musical talent. (3) Under *abnormal anthroponomy* are grouped many problems concerning unusual behavior, i.e., behavior which departs markedly from the norm, or average, of the behavior of adult human subjects. Here are found such problems for study as hysteria, paranoia, hypnosis, and dreams. (4) *Social and racial anthroponomy* studies social behavior. It seeks to describe and explain all forms of interstimulation and response as these are exemplified in such phenomena as custom, mobs, war, and racial contacts. In addition, it seeks to determine whether or not there are any behavior consequences which arise as a consequence of racial membership. (5) *Normal adult anthroponomy* studies the normal, average behavior of the adult human subject. In this field we seek to portray all of the characteristics revealed in normal human behavior and to indicate thereby the fundamental traits of human nature whose genesis, abnormalities, individual differences, and social aspects we have discussed elsewhere.

An adequate understanding of human nature can only be secured by a thorough study of man as represented in all of the fields of anthroponomy. No one field can do justice to the great complexity of human nature. We shall begin our study with a presentation of the general nature of man and of his history on the earth, passing then to the first field of behavior, animal behavior, where we shall secure a phylogenetic approach to the understanding of human nature. Man is closely related to the infrahuman animals both in structure and behavior, and the key to much of his behavior is to be found in the types of responses which they manifest.

REFERENCES

DORSEY, G. A. *Why We Behave Like Human Beings* (New York, 1925).

GRIFFITH, C. R. *General Introduction to Psychology* (Revised edition) New York, 1928.

HUNTER, W. S. "General Anthroponomy and Its Systematic Problems," *Amer. Jour. Psych.*, XXXVI (1925), 286–302.

PERRIN, F. A. C., AND KLEIN, D. B. *Psychology* (New York, 1926).

PIÉRON, H. "La psychologie comme science du comportement et le behaviorisme," *Proc. VIII Internat. Congress of Psych.* (1927), pp. 361–67.

RITTER, W. E. *The Natural History of Our Conduct* (New York, 1927).

SMITH, S., AND GUTHRIE, E. R., *General Psychology in Terms of Behavior* (New York, 1921).

VARIOUS AUTHORS. *Psychologies of 1925* (Worcester, Massachusetts, 1926).

WATSON, J. B. *Psychology from the Standpoint of a Behaviorist* (New York, 1919).

———. *Behaviorism* (New York, 1924).

WEISS, A. P. *A Theoretical Basis of Human Behavior* (Columbus, Ohio, 1925).

WOODWORTH, R. S. *Psychology* (New York, 1921).

MAN AND HIS PLACE IN THE WORLD

Introduction.—Man is the only animal that has developed either science in general or a science of its own behavior in particular. This in itself would make him the most interesting of earth's fauna; but to be a member of the same species with man is to find him doubly fascinating. In such an event one learns through the study of behavior not only something about man but also something about one's self as man. In the present chapter we are to consider the character and history of man, the organism whose behavior is the subject matter of anthroponomy. By so doing we shall not only learn something about the nature of the organism which we are to study, but we shall have forcibly called to our attention the small sampling of human behavior which has so far been utilized in building up our conception of human nature. This latter knowledge should have the very salutary effect of making us cautious in our generalizations concerning human nature and of making us ambitious to extend the field of study beyond its present scope.

The Distinguishing Characteristics of Man.—The zoölogical order of primates to which man belongs is marked by the following chief anatomical characteristics: The limbs are long, and the upper parts are not buried in the body. Each limb has five digits, some of which have flat nails. The great toe or thumb, or both, are opposable to the other digits. The orbits of the eyes are on the anterior aspect of the skull. The brain is large and shows a marked development of the cerebrum. This order of primates includes the monkeys and apes as well as man, who is specifically a member of the group *Hominidae*. Modern man, *Homo sapiens,* differs from the other primates in that he has a habitually upright posture made possible by extensive structural changes in the body. His great toe is not opposable to the other toes; he has no tail; and his brain is

very large and well convoluted. Many other anatomical differences exist, such as differences in teeth, in the shape of the jaw, and in the dimensions of the skull. Although these are important for the identification of human remains, as we shall see below, they need not detain us here.

Modern man differs from other animals not only in anatomy but in the behavior which he manifests. The behavior traits which mark him off most clearly from the other primate or non-primate animals are as follows: (1) He is the only animal who has a written or spoken language, and he is the only animal in whose behavior either written or non-written, verbal or non-verbal language can be clearly demonstrated. There are other animals, notably the raccoons, the monkeys, and apes, where the rudiments of a non-verbal and inaudible language process may be legitimately inferred. Such instances, however, only serve to strengthen the distinguishing character of the language activity in man. (2) Man is the only animal who has a civilization with its accompanying religious, moral, artistic, and scientific forms of behavior. Such forms of activity seem to depend for their existence primarily upon language activity which enables an organism to shape its behavior by symbols as well as by the presence of the objects symbolized. (3) The manufacture and use of tools and fire is a peculiarity of human behavior. No infrahuman animal uses fire, and only the most uncertain and rudimentary use of tools is evident even in the most intelligent of these animals. These, then, are the three primary behavior criteria of *Homo sapiens.* Their mere enumeration is, of course, not sufficient for a complete appreciation of their significance, but the more detailed analysis, and particularly the elaboration of the nature of human behavior which alone can give these criteria their proper setting, is a task for a volume and not for a chapter. Throughout the present book we shall be dealing with human behavior in general, behavior similar in kind to that of other animals and also behavior that is markedly different. In the latter case we shall always suspect the causal influence of language processes and of the tools and institutions which are so closely related to them.

Modern man has a long history of cultural and physical development, a history which is only incompletely known and which from the nature of the case must always remain more or less incomplete. His behavior and structure are the result of the long ages of change and development which have been necessary for the evolution of the human from the prehuman type. A brief survey of this prehistorical phase of man's development will give us a better appreciation of his present status and will also help us to develop an objective and less personally biased view of him.

The Antiquity of Man.—The antiquity of man must be judged from the age of the geological formations in which the remains of his body and of his activities are found. Such geological dates are never stated with accuracy in terms of days and years, but rather they are indicated in terms of thousands of years. The best, therefore, that can be expected is that we shall be able to say that human remains have or have not been found in geological formations antedating the glacial periods, and that the geological formations in question were probably laid down not less than, let us say, 1,000,000 years ago. Table I summarizes the geological epochs and the chief forms of life since the Triassic period. With the forms of life which had already appeared at this time and which continued, we need not here concern ourselves. For our purpose the important thing is to note man's place in the geological series. It is to be remembered, however, that the evidence on man's antiquity is always composed of those portions of his skeleton and products of his labors which happen to have been preserved and which also happen to have been found. The conclusion drawn from material of this character must always be that man has existed at least for the period of time in question. The necessary implication is, however, that man must have existed for an undetermined period prior to the deposition of the remains.

Table II elaborates the upper portion of Table I, using material gathered in Western Europe, where the field has been most thoroughly studied. The two columns on the left contain the geological names for the periods. The third column gives the chief

types of man for whose existence definite skeletal evidence has been found. Column 4 lists the type of cultural remains associated with the periods, and the last column gives some indication of the time

TABLE I

MAN'S PLACE IN GEOLOGICAL HISTORY ACCORDING TO OSBORN

Major Divisions	Periods and Epochs		Advances in Life	Dominant Life
Quaternary	Holocene	Recent alluvial	Rise of world-civilization	Age of man
			Industry in iron, copper, and polished stone	Iron, Bronze, and New Stone Ages
	Pleistocene or Ice Age	Postglacial stage Glacial stages	Extinction of great mammals Dawn of mind, art, and industry	Men of the Old Stone Age
Tertiary	Pliocene	Late Tertiary	Transformation of man-ape into man	Age of mammals and modern plant life
	Miocene		Culmination of mammals	
	Oligocene	Early Tertiary	Beginnings of anthropoid ape life	
	Eocene		Appearance of higher types of mammals and vanishing of archaic forms	
	Paleocene		Rise of archaic mammals	
Late Mesozoic	Cretaceous		Extinction of great reptiles	Age of reptiles
			Extreme specialization of reptiles	
	Comanchian		Rise of flowering plants	
Early Mesozoic	Jurassic		Rise of birds and flying reptiles	
	Triassic		Rise of dinosaurs	

intervals which have elapsed since the events recorded. One must not infer from this table, however, that the various types of men and culture were strictly successive and non-overlapping, or that they were confined to the temporal limits indicated. Peoples in Western Europe existed well into historical time who were in the neolithic stage of culture. The North American Indians were using well-worked stone tools, bows and arrows, and pottery when discovered by Columbus in 1492 A.D. Although the Indians lived in

TABLE II*

Geology		Man	Culture	Years
Quaternary	Recent	Living Races	Neolithic, Historic	
				10,000
	Pleistocene	Cro-Magnon	Upper Paleolithic	
				25,000
		Neanderthal	Lower Paleolithic	
				50,000
				100,000
		Piltdown	Eolithic	
		Heidelberg		
		Pithecanthropus		500,000
				1,000,000
Tertiary	Pliocene			

* From Kroeber

the vicinity of accessible supplies of these minerals, copper and iron ores were not utilized.

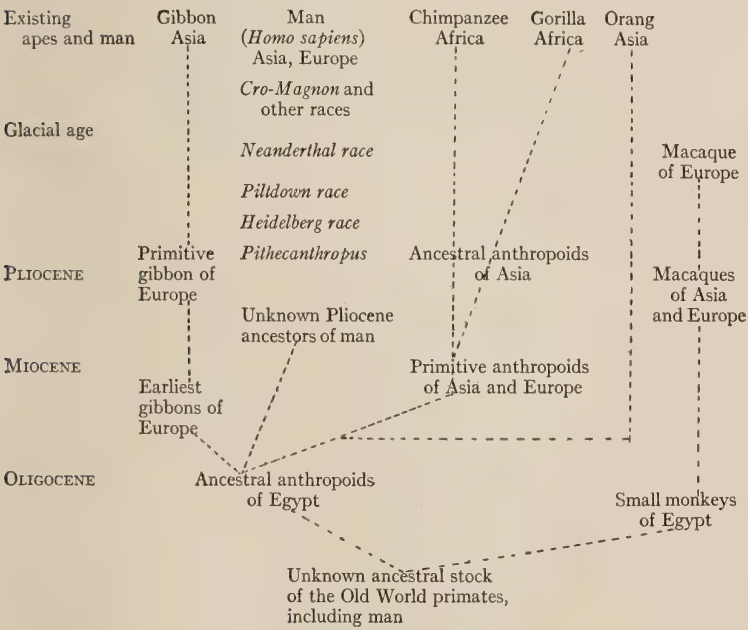
Man's Ancestral Relationships.—Present-day opinion holds that at some remote period in the past there existed an ancestral stock from which man and the other primates have developed. Table III presents a possibly correct statement of the genealogy of the primates. Monkeys are less closely related to man than the gibbons and the anthropoid apes. The monkeys are therefore represented as diverging from the ancestral stock at the earliest date. Sometime in the Oligocene period the group from which *Homo*

sapiens was to develop branched off from both the gibbon and the anthropoid groups.

The Earliest Types of Man.—Let us now pass briefly in review certain typical skeletal finds relating to prehistoric men. In 1891 a Dutch physician, Dubois, discovered human remains in the

TABLE III

Modified from Osborn



early Pleistocene deposits on the island of Java. The only portions of the skeleton found were the top part of the skull, two molar teeth, and a thigh bone. Although one cannot be certain, authorities believe that all of the remains belonged to a single individual. Dubois gave the name *Pithecanthropus erectus* to this early type, which was more human than ape, and yet which was, and is, more primitive than any other human remains yet found. The structure of

the thigh bone indicates an animal that walked upright. The skull had a brain capacity about midway between that of modern man and that of a gorilla. The forehead of *Pithecanthropus erectus* was low, and a heavy bony ridge, the supra-orbital ridge, extended above the eyes. No cultural remains of stone or other material were found.

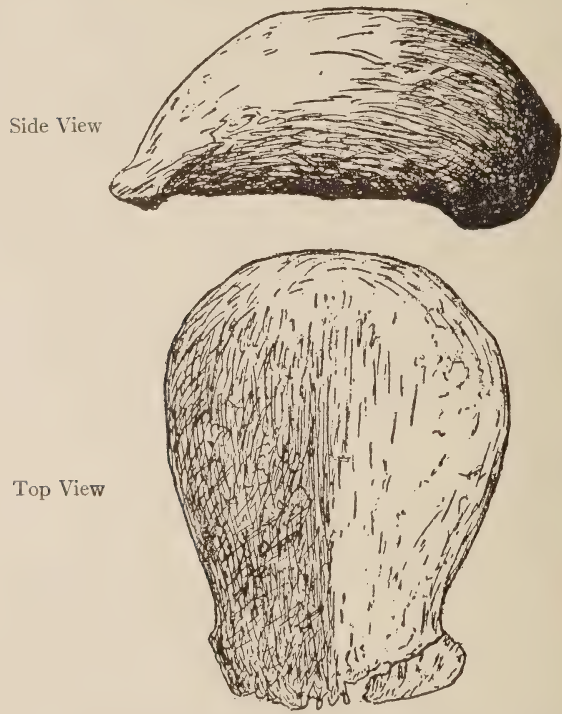


FIG. 1.—Skull of *Pithecanthropus erectus* (from Munro, after Dubois)

In 1907, near Heidelberg, Germany, Schoetensack found a jaw bone with many teeth intact deposited in a formation which was probably laid down in the period following the second ice age. The jaw is more massive than that in any living race of men, but the teeth are distinctly human. Marked canine teeth and the parallel-

ism of the sides of the jaws, both ape characteristics, are absent, as can be seen in Figure 2. The Heidelberg man must have lacked any real chin, but he surely possessed powerful muscles for mastication. No cultural remains were found in connection with the Heidelberg jaw.

In 1911 Dawson found some skull fragments in a gravel bed on Piltdown Common, Sussex, England. During subsequent years the finds from this deposit increased, until now it is possible to add the Piltdown man to the early types of man. Anthropologists differ greatly with respect to the age to be assigned the deposit. The age which is here given, 100,000 years, is that used by Kroeber, although Osborn would place the remains as early as the Late Pliocene. *Eoanthropus dawsoni,* the "dawn man" of Piltdown, had a jaw which did not differ greatly from that of a modern chimpanzee. The cranium, however, had a large brain capacity. In the same sand deposits investigators found flints which had been crudely chipped and which had apparently served as tools either for *Eoanthropus* or for some contemporary.

The Neanderthal race in Western Europe has left us many specimens, some of which are nearly complete skeletons. These specimens have been found in Spain, France, Germany, Belgium, and Austria-Hungary. This is the race that was apparently dominant in Western Europe during the latter part of the third interglacial period and through the fourth glacial epoch. This period is that of the latter half of the Old Stone Age, and its beginnings offer us, in the form of charred wood and bones, the first positive evidences of the use of fire. The Neanderthal man has been described by Osborn[1] as follows:

> An enormous head placed upon a short and thick trunk, with limbs very short and thick-set, and very robust; the shoulders broad and stooping, with the head and neck habitually bent forward into the same curvature as the back; the arms relatively short as compared with the legs; the lower leg, as compared with the upper leg, shorter than in any of the existing races of men; the knee habitually bent forward without the

[1] H. F. Osborn, *Men of the Old Stone Age* (1915), p. 243

Fig. 2.—"A massive Eskimo jaw (above), the Heidelberg jaw (center), the jaw of an orang (below)" (from *Men of the Old Stone Age*, copyright 1915, 1918, by Charles Scribner's Sons. By permission of the publishers).

power of straightening the joint or of standing fully erect; the hands extremely large and without the delicate play between the thumb and fingers characteristic of modern races.

The Cro-Magnon race, which authorities believe to have been the direct ancester of living races and consequently a member of the species *Homo sapiens,* seems to have entered Western Europe at the close of the fourth and last great ice age. The members of this race were unusually tall and large brained, even by present standards. They were probably also swift of foot, and they possessed a skill in handiwork much superior to that of the Neanderthal race with whose remnants they came in contact. We cannot tell whether the Cro-Magnons exterminated, drove out, or merely supplanted the Neanderthals, but we do find that the remains of the former race immediately succeed those of the latter. In a later section we shall have occasion to compare the cultural achievements of these two types of early man.

Authorities claim to be able to recognize descendents of the Cro-Magnons in present-day Europe, but with the close of the Old Stone Age some 10,000 years ago this race was being superseded by the now living races of Europe, who therefore carried on most of the achievements of the New Stone Age.

Living Varieties of Homo sapiens.—Of the early types of man described in the foregoing perhaps the Cro-Magnons were the only ones who belonged to the species *Homo sapiens. Homo neanderthalensis* was probably another species and was possibly inferior in ability, as it was certainly inferior in achievement. In the fossil deposits of Europe we find no evidence of the cross-breeding of these species, although data from living races would have led us to expect that the Cro-Magnons would have enslaved the women of the Neanderthals. If a crossing did not occur it was probably due to an inter-infertility of the species, such as would account at the present for the impossibility of crossing many existing species of animals.

All living types of *Homo sapiens* are not only fertile *inter se,* but their offspring are also fertile. Whatever differences there are,

therefore, between the different types of living men are not species differences. The question, then, arises: Are there any races, or varieties, of *Homo sapiens?* Although the problem of race determination is a difficult one, where the authorities do not agree, we shall recognize three main varieties of man with their subvarieties as follows: Caucasian (Nordic, Alpine, Mediterranean, Hindu), Mongoloid (Mongolian, Malaysian, American Indian), Negroid (Negro, Melanesian, Black Dwarfs). Of these the first three subvarieties of the Caucasian race dominate Western Europe of today. The same three groups are dominant in the United States of America, but there are also large numbers of American Indians, Mongolians, and Negroes.

Cultural Achievements of Prehistoric Man.—The story of the cultural achievements of man during the Pleistocene and recent geological times can only be told, even in the slight detail that it is known, in whole books devoted to that subject. All that we can do is to mention what appear to have been the epoch-making discoveries marking man's progress from a merely animal mode of life to his present civilization. We have already pointed out the chief structural and functional differences between modern man and the animals below him. And it is only reasonable to infer that the distinctly human achievements are causally related to these differences. As language behavior was perfected we may well assume that primitive man was more and more capable of making inventions himself or of learning new modes of adjustment from the neighboring tribes through whose ranks the mastery of such novelties was diffusing. We cannot say, however, when or how language behavior appeared. It is indeed a matter of great regret that the student of human behavior has but little of certain knowledge to report concerning the essentials of the acquisition of language by the young of modern man. This is one of the anomalies of the science which results from a too-prolonged preoccupation with studies carried out upon adults. It is only proper to add that no one has determined by observation and experiment wherein the essential differences lies between the vocal behavior of the parrot and the

vocal behavior of man. If we are thus unable to solve the language problem in either of its most important aspects for living man, we may well be pardoned for our reticence concerning the early forms of this behavior in prehistoric man. The advent of records, written or engraved upon stone or brick, marks the beginning of history; but for great periods of time prior to the making of such records it is but reasonable to suppose that messages were sent from place to place through the medium of markings on stone or on more perishable materials. Written language we must rank as one of man's greatest achievements, although the final fundamental step of using symbols which stand for sounds (phonetic writing) in place of symbols (pictorial) which stand for objects was only made about 1000 B.C. But let us turn back to the period of *Pithecanthropus erectus* and record what we can of man's cultural accomplishments.

The first definite remains of human workmanship which we have are the early crudely chipped flints, *paleoliths*, of the Old Stone Age, which began in the third interglacial period. These tools seem not to have been highly specialized nor to have required great skill in the making. Usually one edge was chipped for scrapping or cutting and the other edge was left rounded for the hand. During the thousands of years which preceded the third interglacial epoch and which followed the first glacial age, the years of *Pithecanthropus erectus* and *Homo Heidelbergensis*, even more primitive tools must have been used, sticks and unfashioned stones picked up and manipulated in a more efficient and yet in a similar manner to that employed by modern apes and monkeys. It should be said also that many flints have been found which may have been chipped by early man but which also may have been fashioned by geological factors. These *eoliths* are widely distributed both in space and time; whether or not they were fashioned by man, they are clearly the type of stone which the earliest man would have found useful. The problematical eolith is our only cultural finding before the paleoliths of the third interglacial period. During this epoch and through the fourth glacial period the remains show a

more and more skilful working. Kroeber[2] sums up this period, dominated by the Neanderthals, and contrasts it with the following epoch, dominated by the Cro-Magnons, in the following words:

> The longest step forward in the development of European Paleolithic civilization comes in the passage from its Lower to its Upper phase. Before this transition, new achievements were rare and their total small. The use of fire, of flint cores and flakes, of fracturing and retouching, possibly the use of wooden handles, a minimal employment of bone, and a definite disposal of the dead, about sum up known human attainments to the end of the Lower Paleolithic.
>
> Compared with this stock of culture, that of the Upper Paleolithic is elaborate. Bone awls and weapon points; shell necklaces and armlets; clothing; painting of the dead; sculpture and engraving—a greater number of elements than the Lower Paleolithic had been able to accumulate in perhaps 75,000 years—appear in the Aurignacian. The foundations of the whole of the Upper Paleolithic civilization were laid in this period.

During the later portions of this age needles, lamps, harpoons, spears, and throwers were introduced, as well as better artistic work through the development of line drawing and the use of color (see Fig. 3).

When we pass from the later part of the Old Stone Age, the Paleolithic, to the New Stone Age, the Neolithic, where the modern races of Western Europe begin to overshadow the Cro-Magnons, we come to the period of pottery, of the bow and arrow, of the domestication of the dog, of agriculture. The cultural changes which these advances imply are tremendous. Man could have a more abundant food supply, not only through his agriculture, but through his increased efficiency as a hunter which the bow and the dog made possible. Agriculture would halt his nomadic life and force him to make more complicated social adjustments. With his pottery he could cook and store food better. The acquisition of the dog was the forerunner of the domestication of the horse, the cow, the sheep, and the goat. The increased manual skill required of man during the Neolithic age, the necessity for planning and wait-

[2] A. L. Kroeber, *Anthropology* (1923), pp. 395–96.

ing, if an adequate harvest was to be secured, and the co-operation of village life, all combined to carry man to a cultural level in which one may descern most of the traits of later civilization.

The age of bronze succeeded the Neolithic, to be followed in its turn by the age of iron. The discovery of the metals and the way to work them gave man potentially all that industrialism has

Fig. 3.—Drawing of a bison and an unknown animal, found in a terminal passage of the Altamira cave, northern Spain. (From Munro, after Breuil.)

later brought forth. Better tools and more dangerous weapons were now possible. War seems to have been waged in Western Europe to a degree not before known. The better control of the food supply and the favorable climatic conditions encouraged a great increase in population, with the consequent necessity for facing increasingly difficult problems of social organization.

Man has not yet passed beyond the use of metals, but there has been introduced into the social order a factor which charac-

terizes modern civilization as specifically as the crudely chipped flints distinguished that of the Neanderthal. This factor is the scientific method. Probably Paleolithic man also observed phenomena and drew inferences in a dependable manner. Certainly the Greeks used the method. And yet only after the Renaissance can we say that the peoples of Western Europe were committed to a civilization in which the use of the scientific method was a vital part. In so continuous a process as the development of man and his cultural behavior, it is usually misleading to place emphasis upon dates. However, for the sake of comparison with the previous stages of man's progress, we shall take the year 1600 A.D. to indicate in round numbers, not only the period in which Galileo discovered the fundamental laws of moving bodies and so laid the foundation of modern physics, but also the period in which Francis Bacon formulated the principles of scientific induction. This year, furthermore, is but shortly prior to Newton's classical work on gravitation.

These cultural achievements of man, which we have so briefly sketched, represent his accomplishments in the realm of learning (habit and custom) made in an endeavor to adjust himself to his environment. Man shared—and still shares—with the infrahuman animals certain internal physiological processes like hunger, thirst, sex needs, and those processes which lead him to remain in an optimal environment. But there also developed in man language behavior and an unusual capacity for learning which gradually enabled him to construct tools for the better solution of environmental difficulties. Man's behavior accomplishments thus became cumulative from generation to generation. The forms of response perfected in one were passed on to later generations and to neighboring peoples in a way and to an extent never found in the infrahuman organisms.

We need not here specify man's early environment in detail. We need not elaborate the fact that great changes in climate occurred at the time of the ice ages, nor that strange and now extinct forms of animal life were man's enemies in Western Europe and

wherever else he migrated. It is often said that such rigorous conditions put a high premium upon skill in the solution of life-problems. Probably, however, due to a simple social organization, the strain of competition was not so great as it is today, although it undoubtedly concerned different problems from those of the present. Man's survival and development is no more remarkable than that of other relatively defenseless animals, but his type of development is markedly different from all others by virtue of his unique characteristics which made that which we call culture possible.

A Graphic Record of Man's Progress in Civilization.—It will be interesting to compare a record of man's progress in civilization with the curves of learning secured in experiments with animals in the laboratory. Let us first consider briefly the conditions under which curves of the latter type are secured. A problem is set for solution. Under laboratory conditions the experimenter sets the problem, but under the conditions of the animal's natural habitat, environmental changes themselves set the problem. In either case the problem for solution must be related to the fundamental life-processes of the animal, processes such as the acquisition of food and bodily comfort and the manifestation of sex activity. Under these conditions when the animal is given repeated opportunities to attempt the problem, progress is made and the solution is finally attained. Curves may now be drawn which will show the amount of time in each succeeding period of work from the beginning to the end of the learning. Figure 11 shows a learning curve based upon data gathered in an experiment on maze-learning in the white rat.

In Figure 4 we have constructed a graphic record which represents man's gradual acquisition of those complex habits which are the components of his present civilization. To be sure, the exact numerical data for such a curve are not known, and yet, with figures which are as large as those in the early part of the curve, where the greatest uncertainty exists, an error of a few thousand units would not materially alter the form of the curve. If we assume that near relatives of *Homo sapiens* appeared in Western

Europe about 500,000 years ago and that the Old Stone Age began about 100,000 years ago, we have (*A*) a period of 400,000 years of human activity prior to the creation of the cultural elements of the Paleolithic. During this and the subsequent periods represented on our graph we must think of man, influenced by such incentives as hunger and the need for mating and bodily comfort, gradually acquiring those habits of life and those acts of skill in fashioning tools which resulted in the cultural characteristics of the Lower Paleolithic. A further period of 75,000 years (*B*) was necessary before man, under the influence of the same incentives, but now aided as well as hindered by the habits of the Old Stone Age, attained the degree of civilization of the Upper Paleolithic. To what extent the time required was reduced by the introduction of the Cro-Magnon racial element can not even be estimated. We have no reason to believe, however, that the Upper Paleolithic culture was merely superimposed upon Western Europe by a new and superior race. There is a continuity of cultural development even though a new race with new habits of adjustment appeared upon the scene.

Fifteen thousand years (*C*) elapsed before a distinctly new cultural level, the Neolithic, was attained. The next point at which we mark a new epoch is 7,000 years later (*D*) with the appearance of the habits of the bronze age. The use of iron (*E*), making possible by man a still better control of environmental difficulties, is probably two thousand years later than the use of bronze, but an employment of iron on a sufficient scale to constitute an iron age did not appear prior to about 500 B.C.

We have now reached the point in the development of civilization where it is necessary, as we described before, to choose the distinguishing characteristic of man's present culture. We might select the use of steel or electricity, and there can be no question but that each has profoundedly affected man's cultural status. A reasonable justification might also be given for the use of steam or of the internal combustion engine which has made the automobile and the airplane possible. Our choice, however, is of the most fundamental characteristic which prevades present civilization and which has

made possible the foregoing achievements. This is the mastery of the laws of motion by Galileo and the formulation of the scientific method by Francis Bacon. The approximate date is 1600 A.D. We

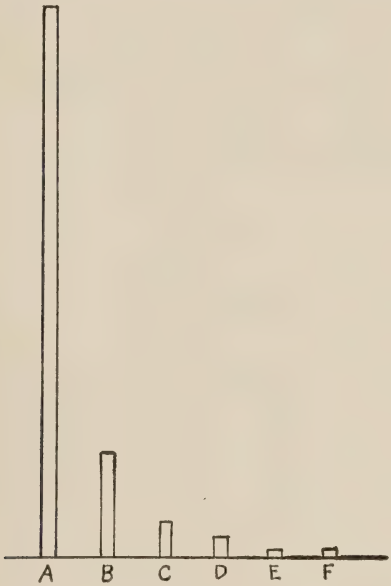


FIG. 4.—A graphic representation of the acquisition of present Western European culture by Europeans. There are many conceivable ways in which the progress represented in this curve might have been accelerated. Man did not work, e.g., 7,000 years *trying to master* the use of bronze. Rather, 7,000 years of the struggle for existence resulted in the cultural habits typified by the mastery of bronze. The same situation is present when a rat is learning a maze. The rat does not work 5 days, e.g., on the second stage of mastering the maze. He works for food for 5 days, at the end of which time he has attained the second stage of mastery. Various forms of tutelage could have decreased man's 7,000 years and the rat's 5 days.

shall therefore mark the last point (*F*) on the curve to represent a duration of 2,000 years from the iron age until man had gotten well started on the scientific age.

The Continuity of Development.—The present topic of the development of man's behavior from the viewpoint of its outstanding cultural characteristics should not be left until the essential continuity of all development is stressed. The epochs which have been indicated in Table II grow gradually one from the other. There are no sudden breaks in the progress, but each stage brings man's behavior appreciably closer to its present form. This, for the moment, final form of behavior or final level of attainment has not been the goal of the progress which we have traced in the sense that man has shaped his behavior with reference to such an end. Rather, present civilization is the goal of man's behavior only in the sense that we as scientific observers arbitrarily choose such a terminus to which to relate all previous accomplishment.

A closely similar situation exists in describing an animal's mastery of such a problem as the maze or in describing a man's mastery of telegraphy. Each point on the learning curves shown in Figure 11 represents a level of skill in dealing with the environment. The final level of attainment, i.e., the goal of achievement, is the arbitrary point at which training is discontinued or at which our observation ends. Progress from point to point is a continuous process. "Points" are selected only as an aid to description and analysis. They are not interruptions in an otherwise unbroken continuum.

The Environment of Man.—Let us turn for a moment from the study of man to a characterization of his environment. The term environment is usually applied only to the sum total of objects which surround an organism and which are the source of those stimuli that affect the animal and so partially determine its behavior. Objects which exist but which do not influence the organism's responses are not essential parts of its environment. Thus copper and iron, prior to their utilization by man, are not properly to be termed parts of his environment, whereas the temperature which prevailed and which influenced the general character of the local flora and fauna as well as man's personal behavior was an important element in shaping his life-history. Such an environment

as we have suggested is external to the animal, i.e., it lies outside of the skin, and so may be termed the extra-cutaneous world. In describing this environment, two methods are theoretically available. Either one may use the terms of everyday language and speak of trees, food, colors, sounds, and temperatures, or one may use the language of physics and chemistry and speak of light rays of specified properties, air vibrations, and electron-proton combinations. The choice between the two modes of speech is partly determined by social convenience and partly by the help in experimentation which may come from the precise formulations of the fundamental sciences.

In addition to the extra-cutaneous environment, there is a subcutaneous one. This latter is the locus of additional factors which influence the behavior of organisms, such factors as muscular contractions of the stomach, dryness of the throat, irritation of membranes, and secretions of glands. For many of these events in the inner, or subcutaneous, environment there are terms in everyday use. Words like hunger, thirst, and pain are at once suggested. For terms to denote other inner conditions, like blood pressure and glandular activities, we must turn to biology.

This subcutaneous environment has long fascinated the students of psychology, who, however, have been led by philosophy to term such an environment mental, or psychic, and to devise a method of introspection for its study. The psychologist, following such philosophers as Berkeley, regards the external world also as mental. To study the "mind," or "experience," of an organism is therefore to study its environment. Psychology, so far as it is a study of "experience" and not of behavior, attempts to enumerate all of the aspects of the total environment and asks in the pursuit of this goal such questions as these: What colors can an animal see? What tones can it hear? Does a point of light in a dark room seem to move? These questions are interesting, but they err in the misdirection of effort which they reveal. They are formulated to throw light, not upon the behavior of the organism, but upon the objects which surround it. The student of behavior is also interested in the

environment, not because this latter is "psychic" or "experiential," but because it controls the responses of the organism. As our discussion proceeds we shall see in detail how the anthroponomist meets his problems. At present it need only be said that the foregoing questions, posed by the psychologist, become the following: Can an animal respond in different ways to lights of different wavelengths, colors, or to air vibrations of different frequencies, tones? Does an animal respond to a point of light in a dark room as though the light moved?

The significance of the change in the form of the questions is tremendous for the science. The behavioristic formulation places the emphasis upon a description of the animal, and not of the environment. This latter problem, if speculative, belongs to philosophy, and if empirical it belongs to such sciences as physics, chemistry, and geology. Such a change in point of view is as significant for the study of man as the shift from the Ptolmaic to the Copernican system of astronomy was for that science. Each change has meant an entire rearrangement of data and the adoption of a straightforward scientific program after an era of work which was ending in confusion and stalemate.

Certain Limitations of the Science of Human Behavior.—In the preceding pages we have outlined man's history on the earth, so far as it is known. It is now necessary to indicate certain of the present limitations and characteristics of the science of his behavior. Practically all experimental studies of human behavior have been made upon members of the Caucasian variety of man. Only recently has the work been extended to the Mongolian and Negro varieties, and this extension has been chiefly in the field of behavior tests of the Binet-Simon type. Present-day anthroponomy is, therefore, essentially a science based upon one variety of *Homo sapiens*. To a very large extent, moreover, the subjects for experimental work have been adults who were enrolled in universities, while the behavior observed has been largely verbal responses to various stimuli. Only in the present century has that intensive experimental work been begun upon children which alone can give

the key to much adult behavior. One of the great merits of the work done by psychiatrists and psychoanalysts lies in the fact that the forms of human behavior which they have studied are more fundamental and vital than any which society will permit us to produce in the laboratory. However, in these fields, as well as in the field of social anthroponomy, a careful scientific control of the behavior studied is exceedingly difficult. To supplement the data which are available for man, the anthroponomist makes use of experiments upon infrahuman animals, although many difficulties arise when any attempt is made to generalize concerning human behavior upon the basis of data gathered from infrahuman organisms. Specific attention has been called to these limitations of the science in order that the reader may be led to adopt a cautious attitude in generalizing its findings beyond the experimental conditions under which they were secured.

REFERENCES

Boas, Franz. *Anthropology.* A lecture (New York, 1908).

Elliott, D. G. "A Review of the Primates," *Amer. Museum Nat. History Mon.,* No. 1 (1913).

Elliot, G. F. S. *Prehistoric Man and His Story* (London, 1915).

Hrdlička, A. "The Most Ancient Skeletal Remains of Man," *Smithsonian Report for 1913* (Washington, 1914), pp. 49–552.

Hunter, Walter S. "General Anthroponomy and Its Systematic Problems," *Amer. Jour. Psych.,* XXXVI (1925), 286–302.

Kroeber, A. L. *Anthropology* (New York, 1923).

Kroeber, A. L., and Waterman, T. T. *Source Book in Anthropology* (Berkeley, California, 1920).

Osborn, H. F. *Men of the Old Stone Age* (New York, 1915).

———. "Recent Discoveries Relating to the Origin and Antiquity of Man," *Science,* LXV (1927), 481–88.

Sonntag, C. F. *The Morphology and Evolution of the Apes and Man* (London, 1924).

Yerkes, R. M. *Almost Human* (New York, 1925).

PART I. FIELDS OF ANTHROPONOMY

CHAPTER I

PHYLOGENETIC ANTHROPONOMY

Introduction.—Because of man's genetic relationship to the remainder of the animal kingdom much light may be shed upon the nature of his behavior through the study of infrahuman animals. In this latter field one may study behavior uninfluenced by custom, fashions, and language. To this extent the infrahuman organisms offer a simpler subject matter for experimental analysis than is found in man. Whether or not such animals can be more carefully controlled than man is a question which cannot be simply answered. To be sure, the rat, for example, can be kept isolated in a cage all of his life. He can be operated upon at will and can be experimented upon under conditions, such as exposure to wood-alcohol fumes, which would be too fraught with the danger of bodily injury to justify their use on human subjects. And yet through the use of language a control can be exercised over human behavior which is entirely impossible with the behavior of other animals. A human subject can be given complicated commands to execute, and in particular he can be told how to behave in general during an experiment. Although these verbal-response methods may be no more sensitive than the non-verbal methods, they open up a wide field of experimentation with man which has no duplicate with the other animals, but such fields we must examine later in the book.

The Chief Problems.—The problems of animal behavior may be divided into three groups. The first of these concerns the problems of receptor processes. These problems involve a study of the ways in which eyes, ears, taste organs, etc., can be stimulated and so determine behavior. The second class of problems concerns responses, the motor and glandular activity which constitutes the behavior of the organism. Here are the problems of learning, of retention of learned behavior, and of unlearned behavior. We inves-

tigate the formation of specific habits and the interrelations which exist between the various habits. Problems arise concerning efficient learning, transfer of training, interference of habits, the effects upon habit formation of drugs, sex, age, etc. Other questions which concern the speed, efficiency, and kind of learning, and which involve the discussion of imitation, symbolic processes, and intelligence are also to be classed here with learning, inasmuch as they concern either the way in which a habit is formed or the manner of using it after learning. The third class of problems concerns those factors, influential in determining behavior, which are intermediate in location to the receptors on the one hand and the effectors on the other. The study of the structure and function of the nervous system belongs here, as well as the effort to determine the nature and existence of unlearned connections in the nervous system. It is to be remembered that behaviorists are vitally interested in all factors which affect behavior, and that many of these factors seem to lie in the nervous system.

As a result of the exhaustive study of the foregoing topics there will accrue at least the following results: (1) The essential continuity of sensory, motor, and central activities throughout the phylogenetic series will be evident. (2) Light will be thrown upon many aspects of human nature which can be more safely and conveniently studied in infrahuman animals than in man. (3) New points of approach to the study of human nature will arise to be helpful in human studies.

Methods of Study.—Two methods of studying animal behavior are in use: (1) the naturalistic or field-observation method and (2) the experimental method. The first method was used particularly by the naturalists of Darwin's day. It is still used for practically the same purpose, viz., for the observation of the animal in his own habitat, unmolested by experimental conditions. The studies in this field of work cover such topics as the "expression of emotions" in animals (Darwin) and the general observations on such activities as migration, mating, homing, and fighting (Romanes, Morgan, Watson, and innumerable others). This method has

its chief value for psychology in that it suggests many problems for accurate study, for unaided by experiment it can give us little concerning receptor activities or concerning the genesis of types of action. Thus, if a vulture approaches a heap of carrion, or if an owl catches a mouse, field observation can record the fact, but it cannot tell what receptors are involved. Did the vulture smell or see his food? Did the owl see, hear, or smell the mouse? Only careful experiments upon the sensitivity of the animals concerned can give the answer. The same thing is true with respect to the nature and place of imitation and "reason" in animals. Field observations have constantly and insistently recorded phenomenal performances which are held to demonstrate the presence of these powers. Experimentation, however, has practically always either reversed the facts or shown the uselessness of such interpretations.

The experimental method seeks to control the conditions affecting the animal in such a manner that the exact natures of the stimulus and response may be determined. This method is applied under two conditions. In the first place observations may be made of the animal's responses as these occur without any training by the experimenter. We may therefore refer to this as *the non-training experimental method.* Francis Galton (1883) was a prominent pioneer in its use. Going through the zoölogical gardens of London, he sounded high-pitched notes on a whistle, which he carried concealed in his hand, near various species of animals. If the animal tested responded with any movements, Galton concluded that it could hear the tone in question. When carefully applied this method gives conclusive results on the question of mere sensitivity, but it is not so safe where discriminations between objects are involved. Unless, for example, the experimenter can secure one kind of response to sound and another kind to light, there is no way of telling whether or not these two forms of stimulation are different for the animal. Additional work with this method has been done, particularly by G. H. Parker and his students, on hearing, taste, and smell in fish.

The second form of the experimental method is *the training method.* This is the chief mode of procedure used in studying ani-

mal behavior by American students. Most of the data which have been secured have been obtained by training the animal in certain habits of action or in certain habits of discrimination between stimuli. The subject may thus be taught to run through a maze without error or to respond in a specific way in another apparatus when red and green lights are shown. In these instances the fundamental motives employed are hunger and the avoidance of painful stimulation. The animals are fed just enough to keep them in good physical condition. Electric shocks usually serve for the punishment and are given when the animal makes an erroneous response. Perhaps we may best designate this method as the method of gross bodily behavior. A better understanding of this method will come later in the chapter when detailed experimental findings are discussed. The second training method is that of the conditioned reflex.

The Two Training Methods.—The experimental results so far available indicate that the two training methods give different results. We may illustrate this as follows: Using the conditioned salivary-reflex method, the Russian investigators, Pavlov, Bekterev, and their students, have been able to show that the dog is sensitive to differences in the pitch of tones, i.e., that his salivary gland can be trained to respond to auditory stimuli which differ in vibration frequency. Johnson, working with dogs, and Hunter, working with white rats, have been unable to demonstrate such a sensitivity when the method of gross bodily behavior is used. Rats can be trained to run through one path for a noise stimulus and through another when no auditory stimulus is given. Such a habit, however, cannot be set up if the stimuli are tone versus silence. These apparent contradictory results of the two methods are probably not actually contradictory, but supplementary. The conditioned-reflex method is suited to the determination of receptor sensitivity and to the analysis of some of the functions of the nervous system. The method of gross bodily response, on the other hand, reveals only those forms of receptor sensitivity which can condition the animal's total adjustment to environmental conditions. An

auditory receptor may be sensitive to tonal stimulation and yet the animal may be unable to form such habits as feeding, running, and searching upon the basis of such a stimulation. The conditioned-reflex method may therefore be more closely related to physiology, and the gross-bodily-response method more closely related to the naturalistic method of Darwin and his successors. Both methods are valuable means for the investigation of their respective problems.

The Conditioned Reflex.—The essential features of the conditioned-reflex method are as follows: Certain stimuli will without training arouse certain motor and glandular activities, e.g., taste will arouse a flow of saliva; increased light intensity will cause a contraction of the pupil of the eye; and pain will produce a withdrawal of the part of the body injured. These activities are *unconditioned reflexes*. Certain other stimuli which do not naturally arouse the response will finally come to do so if they are presented frequently with the effective stimuli. Thus, as a result of training, saliva may flow from the sight of food or from the description of food, and one's hand may withdraw itself upon the appearance of an idea of a painful object. In this case where new stimuli arouse the response by virtue of the animal's experience, we have a typical *conditioned reflex*. This method of studying behavior was devised by two Russian scientists, Pavlov and Bekterev. It has been used in the United States particularly by Watson and Cason.

It will be seen that the method takes account of the fact that one of the fundamental ways in which modes of action are varied is by changing, not the activity proper, but the stimuli which arouse it. Undue novelty has been attached to the method because most studies have been carried out upon the salivary reflex and upon simple protective reflexes, such as the withdrawal of the foot or the hand from pain, whereas all cases of habit-formation are equally true cases of the acquisition of conditioned reflexes. The term "conditioned reflex," however, has unusual value as a tool with which to work on learning problems because of its objective character. It is in this respect superior to the older term, "association," which has

a subjective connotation. Figure 5 indicates the Pavlov salivary method applied to dogs. By presenting a sound, a light, a taste, etc., with food it can be shown that if the animal is sensitive these objects will soon cause a flow of saliva if presented when food is absent.

A presentation of some aspects of Cason's study will further clarify the method and at the same time acquaint us with some of the aspects of learning. Cason worked with the pupil reflex (contraction and dilatation of the pupil) and with the eyelid reflex

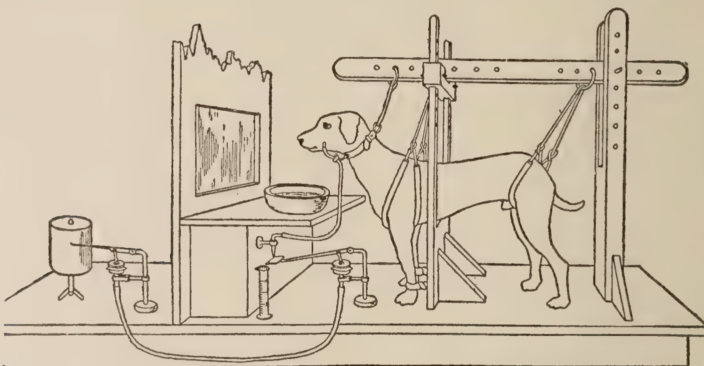


FIG. 5.—The Pavlov salivary reflex method (after Yerkes and Morgulis). Saliva flows from the dog's cheek through the tube, drops down upon a lever, and then flows into a graduated glass. This saliva, falling upon the lever, causes it to vibrate and accordingly to transmit the motion to the marker which records on the rotating drum. The flow of saliva in the graduate can be measured in quantity and then chemically analyzed.

(protective closing of the eyelid) in human subjects. In each case it was found possible so to train the subject that new stimuli would call forth the response. We shall speak further only of the pupillary response. This is aroused prior to training by two stimuli in particular: change in light intensity and divergence or convergence of the eyes. In the present experiment, the eyes were stationary and the effective stimulus used was change in light intensity. The noneffective stimulus to be presented with the light was the sound of an electric bell. Without training, the bell produced a slight dila-

tation of the pupil. If the sound of the bell was presented with a decrease of light intensity, then after sufficient repetition the bell produced a greater dilatation than in the beginning. If, however, the auditory stimulus was presented with an increase in light intensity, then after training the sound of the bell produced the response of pupil contraction. Contraction of the pupil to an increase in light intensity and its dilatation with a decrease in intensity are unconditioned reflexes. The conditioned reflex here is the response of the pupil to sound-stimulation after training.

We shall use Fig. 6 in commenting upon this experiment. The stimulus-response situation prior to training is as follows: $+L$, increase in light intensity, results in C, contraction; $-L$, decrease in

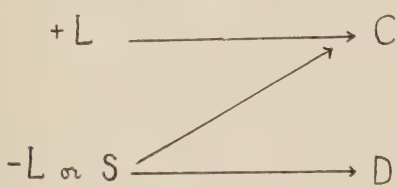


FIG. 6.—Stimulus and response relationships involved in the conditioned pupillary reflex.

light intensity, results in D, dilatation; S, sound of the bell, also results in D. With training S may be connected with C and cause not a dilatation of the pupil but a contraction. If we consider $-L$, S, C, we say that training has resulted in the acquisition of a new stimulus for C. If we consider S, C, D, we say that training has given S a new response. Probably all learning is of this type, every change being reflected both in the form of stimulation and in the form of response, for apparently all forms of stimulation produce some change in behavior.

The experiments and results to be described next represent typical studies of various sensory and motor capacities of animals. They indicate how the problem of relative intelligence in man and animals must be solved. Other things being equal, that animal is

most intelligent that can be stimulated by the most stimuli and execute the most varied forms of muscular responses.

Tropisms.—It will be well to direct our attention first to the responses of animals having the simplest body structure. The responses of these organisms are called *tropisms*. There are many definitions of this term, but to avoid the controversial aspects of the matter we shall define tropism as any unlearned form of response not under the control of a nervous system. These responses are either positive or negative—positive if the animal approaches the

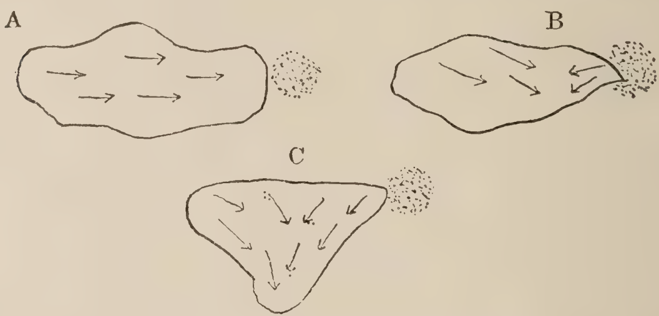


FIG. 7.—A negative tropism in amoeba (after Washburn). The arrows indicate the direction of movement.

stimulus, negative if the animal avoids it. The behavior can best be described with the aid of Figures 7 and 8. Figure 7 represents an amoeba coming in contact with a drop of chemical. The response, or tropism, consists in an extension of the protoplasm at some point of the animal's surface. Thus the amoeba gradually avoids or withdraws from the stimulus drop. If, in place of a chemical, light be used, the amoeba may either approach the light or avoid it, its response depending upon conditions that need not concern us here. Figure 8 represents a negative response of paramecium to contact. Swimming in the direction of arrow No. 1, the organism encountered the new and harmful stimulus *A*. Thereupon the beat of the cilia (fine hairs on the surface of the body) was reversed in direction, and the paramecium backed away, turning at the same time

away from the mouth-side of its body. The beat of the cilia was now again reversed, and the organism again swam forward. The same response would be made to any injurious object. Paramecium reacts to favorable objects by remaining in the favored locality. It accomplishes this by giving the negative response whenever its swimming activities threaten to take it beyond the optimal region.

In the simple behavior of these unicellular organisms we have the prototype of all higher forms of response. The amoeba, for example, shows sensitivity, motility, and conductivity (the transmission of energy in some form from the point of stimulation to the

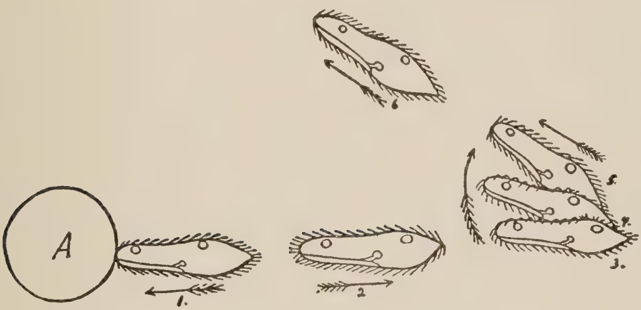


FIG. 8.—A negative tropism in paramecium (from Washburn after Jennings).

point of response). Subsequent evolution adds no new function but merely brings forth special structures to perform them—receptors, muscles, and glands, and nervous tissue. With this more complex development, organisms become sensitive to more varied stimuli, and they accordingly respond in more highly varied ways, i.e., they become more intelligent. The nervous system, whose function is the co-ordinating of sense organ and motor and glandular activities, keeps pace with this development of sensitivity and motility. We shall trace its growth briefly in the chapter on "The Nervous System."

There is another way in which these simple organisms present facts of importance. They are sensitive (with almost no exception)

to all the classes of stimuli that affect higher organisms. (Accordingly, we are able to call no one sense the most primitive.) Tropisms are classified according to the stimuli that arouse them as: chemotropisms, phototropisms, geotropisms (responses to gravity), stereotropisms (responses to contact), rheotropisms (responses to water currents), etc. These tropisms are positive if made toward the stimulus and are negative if made away from the stimulus. Two practical cases of importance are the positive chemotropisms, which undoubtedly lead bacteria to attack certain tissue, and those that result in the sperm finding the ovum.


FIG. 9.—Stentor

Jennings' Explanation of Behavior.—One of the most important contributions to the understanding of behavior is to be found in H. S. Jennings' *Behavior of Lower Organisms* (1906). After an extensive study of these forms, Jennings summarizes the factors which control behavior under the following general headings: (1) external stimuli, such as light, heat, and contact; (2) progressive internal physiological states, particularly those connected with feeding and fasting; and (3) internal physiological conditions determined by the previous activity of the organism. In attempting to explain the behavior of an organism, whether it be amoeba or man, it is insufficient merely to describe and measure the external stimuli and responses. Account must be also taken of the internal stimulating conditions and of the effects of previous activity or training. This latter point can be illustrated in the behavior of Stentor. If Stentor (Fig. 9) is stimulated on its disk by a jet of water, the little animal quickly contracts into its tube. If, however, the stimulus is repeated about one minute later, after the animal has resumed its normal activity, this normal activity is continued and no observable response is made to the jet. In order to explain the non-appearance of a response to the stimulus account must be taken of the previous activity of the animal. Or our illustration can be drawn from animals high in the zoölogical

scale. Thus the record which a rat will make in running through a maze will depend partly upon whether the animal is or is not well fed before the test, whether it is or is not frightened, and whether it has or has not been in the maze before. In those organisms possessing a nervous system the progressive internal changes and the effects of previous training influence behavior largely through the nervous system.

Instinct.—Our chief discussion of instinct will be given in the chapter on "Social Anthroponomy" and in chapters ii and iii of Part II. In the present account we shall indicate only certain broad characteristics, offering as illustrative material some observations on the behavior of kittens. Instinct is the term applied to those forms of response which can be made without practice. Here belong such activities in animals below man as eating, flying, drinking, killing, sex, nest-building, etc. There is no need to assume that these are mysterious urges; nor are they connections in the nervous system, for the distinction between that which is unlearned (instinct) and that which is learned (habit) can be made without reference to the nervous system. Rather, these observable forms of behavior themselves, so far as they are unlearned, are the instincts. Some of the inherited, unlearned forms of response appear at birth, while others, like that of sex, are considerably delayed. Learned behavior is acquired as a modification and recombination of inherited forms of response after the fashion of the process typified in the conditioned reflex. Far the greater portion of our knowledge of the unlearned forms of behavior comes from the study of animals below man, since it is here that instinct appears least transformed by habit. In man, social control, a high learning capacity, and the ability to think make the instincts less accessible to study. As a result, where human instinct is discussed much confusion has been introduced by the failure to relate human and animal behavior and by the consequent attempt to read into instinct some of the characteristics discerned in man. This anthropomorphic point of view must be repudiated in the studies of instinct as it has been in those of habit.

The following quotations from Yerkes and Bloomfield's[1] study of the behavior of kittens in killing mice will illustrate both the nature of instinct and the method of determining whether or not a given response is unlearned. Each kitten was tested by being placed in a small wire cage with a mouse. Here it was left for 15 minutes and its behavior noted. During the first four weeks of life no kitten gave specific responses to the mouse. We shall now illustrate what happened by describing the behavior of one kitten. Kitten No. 4, when one month old, gave a new type of response, one which had not previously occurred.

She noticed the mouse, soon after she had been placed in the cage, as it moved near her, and quickly seized it in her mouth, growling the while. The mouse escaped and the kitten gave chase, but failed to recapture it before it had climbed to the top of the cage.

When five weeks old, No. 4 was again tested as follows:

No. 4 smelled about the cage as though searching for something. She finally saw the mouse in one corner of the cage and made for it, but she was too slow to catch it, for the mouse had quickly darted to the top of the cage as the kitten began to move. The kitten continued to the place where she had seen the mouse the instant before, and after feeling and smelling in the corner where the mouse had been she licked her paw. Soon she located the mouse at the top of the cage. She approached, reached up with one paw and touched the mouse, then drew back. This was repeated three times. Had the mouse run from its position, the kitten doubtless would have attempted to catch it. . . . . As the time for the test had elapsed, the kitten was now removed to the animal-room.

When tested next, two days later, on being placed in the cage, with back arched she pursued the fleeing mouse to a corner and then spit and struck at it with her paws. Next she bent her head low and sniffed at it. She watched it closely for a time, showing sustained attention. When the mouse finally attempted to escape from the corner, the kitten made a dash for it, hissing and growling. On overtaking her prey, she drew back slightly, spitting and repeatedly unsheathing and sheathing the claws of a paw which she extended toward the mouse. The mouse next made a sudden

[1] Robert M. Yerkes and Daniel Bloomfield. "Do Kittens Instinctively Kill Mice?" *Psych. Bull.*, VII (1910), 253–63.

dash across the cage. Like a flash the kitten was upon it mouth and claws. With the mouse held firmly by the head, the kitten began to growl. In a few seconds she shifted her hold and taking the nose of the mouse she bit it repeatedly. Then followed a period of worrying during which the mouse several times tried to escape only to be seized by some part of its body and vigorously chewed or struck with the paws of its captor.

These observations aid us in thinking of instinct as a complex, organized mode of unlearned response appearing in a form which is typical for the given species. Uusually the behavior is biologically useful from the date of its initial appearance.

Receptor Processes.—So far in our account of animal behavior we have commented upon problems, methods, and inherited forms of response. We shall now present briefly certain typical studies upon receptor processes and then turn to an account of habit formation as this is exemplified in relatively simple and relatively complex forms of behavior. Let us first take up the receptor processes arising from the activity of muscles and inner organs, kinaesthetic and organic sensitivity. These processes are usually studied by the use of an apparatus termed the maze. Figure 10 shows the plan of a maze used in the study of small animals. The animal starts at the entrance and must run to the food box, in the center, where it secures food. On the first trial the animal probably requires 20–30 minutes, finally blundering into the food box by accident. On subsequent trials the run is made in shorter and shorter time and with fewer and fewer errors, until the animal runs about 2–4 feet per second (if it is a rat) and makes no deviations from the true path. A typical learning curve is shown in Figure 10, representing the gradual way in which the time of work decreases from trial to trial as learning proceeds. Watson showed that white rats can learn this problem in terms of kinaesthetic (nervous impulses coming from the muscles, joints, and tendons) and organic receptor processes. Sound, vision, and smell were unnecessary. Later experiments have supplemented this study by showing that cutaneous stimulations are also necessary. After the problem has

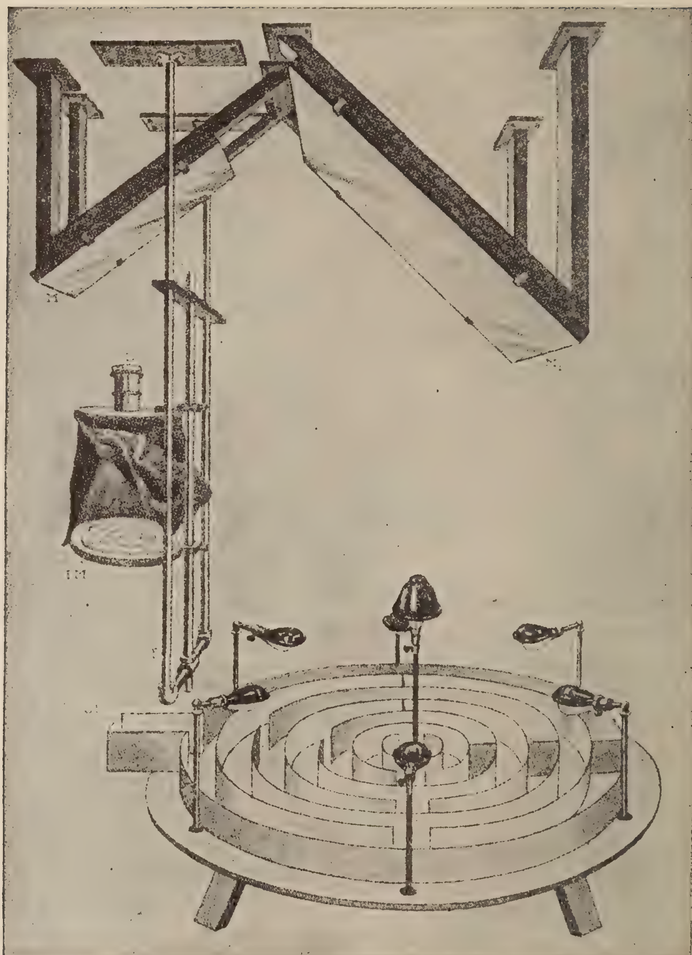


FIG. 10.—The circular maze and camera lucida attachment (from Watson). *SB*, entrance; MM_1, the mirrors; *L*, lens; *IM*, image of maze and animal that is in it. This apparatus makes possible the accurate recording of the distance traversed by an animal. This is done by tracing on *IM* the path followed there by the animal's image. Such a record is important in showing the gradual formation of the habit.

been learned, the rat runs the maze as automatically and as surely as we go into our bedchamber in the dark, walk in a certain direction, reach up and touch the light. The response in both cases is guided by kinaesthetic and cutaneous receptors. If the maze is constructed so that it can be shortened by taking out a section without disturbing the interrelations of the turns, rats that have learned the problem previous to the change will now run into the

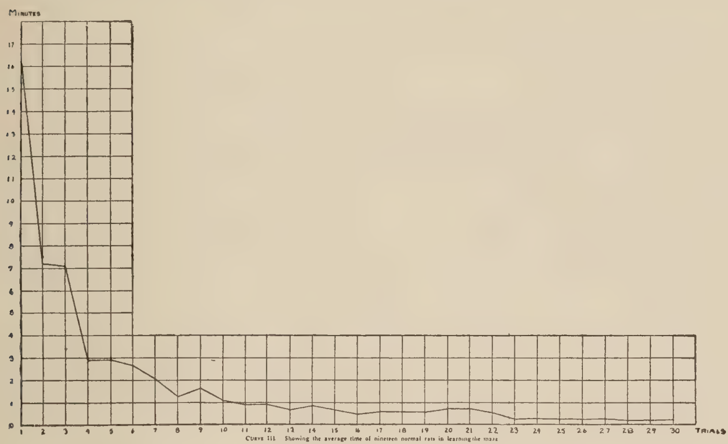


FIG. 11.—A learning curve for the Hampton Court maze, based upon nineteen normal rats (after Watson).

ends of the alleys and run past the proper openings, just as we would fail to reach the light if someone had moved it. Vincent has presented evidence suggesting that it is possible for rats to utilize odor, contact, and vision in learning the maze if such differences are made sufficiently prominent. However, as the response becomes automatic it comes more and more under the control of the muscle and skin senses, until finally the other sensory cues lose their function.

A very large number of experiments have been performed on vision in animals, particularly by Hess, Watson, Yerkes, Johnson, Lashley, and H. C. Bingham. The chief experiments have been

made on visual acuity, pattern discrimination and the sensitivity to white and colored light. Especial interest attaches to the last problem. Do animals respond to monochromatic light? In the earlier work colored papers were used as sources of light. In order to secure its food, the animal was required to select a certain color located irregularly relative to other colors. These experiments brought

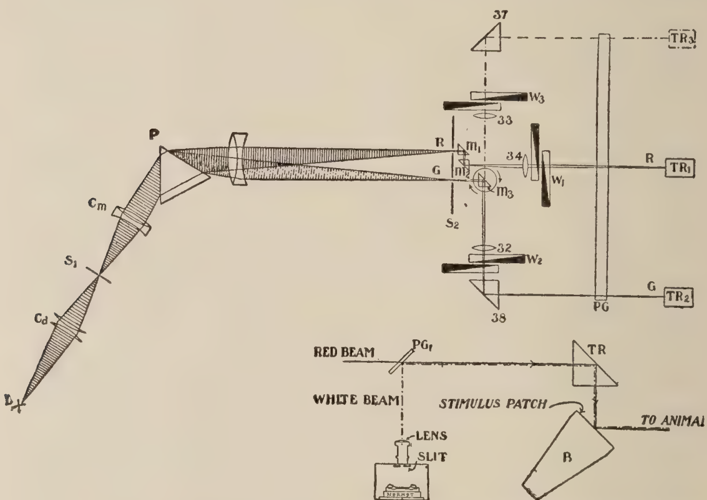


FIG. 12.—Ground plan of the Watson color apparatus. The pathway of the light is traced from the source at L through the lenses and prism to the strip S_2, where the particular color rays to be used are selected. These are permitted to pass and are finally brought to a focus on the plaster-of-Paris reflectors shown at B of the insert. The wedges W_1, W_2, W_3 serve to decrease the intensity of the light. The saturation or amount of color can be reduced by introducing white light, as shown in the insert.

forth positive evidence of color sensitivity, but the results must be discounted because of the many uncontrolled sources of error. Even a color-blind individual might have succeeded in the tests, for such papers differ in intensity and in amount of color reflected (saturation) as well as in color proper. It is particularly difficult to interchange the intensity differences sufficiently to be sure that

they and not the wave-length, i.e., the color, were the basis of the animal's response. Let us suppose, for example, that two colors, red and green, are shown to the animal, food always being given when the red is selected. If the animal finally succeeds in choosing the red 80 per cent of the time, the cause may lie in the fact that the red is the darker of the two and not because of differences in color. And no change that can be made in the red papers may be sufficient to make the red the more intense and so cause the animal to fail in its response.

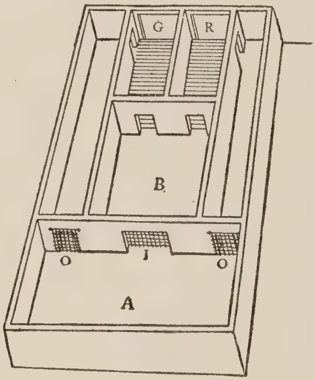


Fig. 13.—The Yerkes discrimination box described in the text. The plaster-of-Paris strips, circles, patterns, etc., that are to be discriminated by the animal appear at G and R, presented in an irregular order to prevent the animal's use of position habits.

In order to secure colors that will be strictly monochromatic and whose intensities will be thoroughly under control, Watson devised the apparatus whose general plan is shown in Figure 12. This apparatus is entirely concealed from the animal tested, who is stimulated only by the colors cast upon the Plaster-of-Paris strips. These strips are at the end of a two-compartment discrimination box devised by Yerkes and shown in Fig. 13. The animal is introduced at *B* and must go through either alley *G* or *R* in order to return to *A* and secure food, which is given only as a reward for work done. If mistakes are made, slight electric shocks can be given through the wires in the alleys. Tests have been made with this apparatus on monkeys, rabbits, and rats. Although the actual results have varied somewhat from test to test, almost no evidence has been brought forward indicating that the animals concerned could form habits in response to stimuli differing only in wave-length. K. S. Lashley (1916), however, has secured evidence

of color sensitivity in chicks which leads him to believe that they react to color differences quite as readily as to intensity differences.

The biological significance of tests of this character is very great. It is often said, e.g., that some animals are marked with colors as a protective device against enemies or as a factor in sexual selection. Whether or not this is true depends partly upon whether or not the animals concerned can respond to differences in the wave-lengths of light.

The difficulty of demonstrating color vision in animals may well lead us to inquire concerning the detailed procedure used in such experimentation. Three chief methods may be noted. (1) If the Purkinje phenomenon is present, color vision almost certainly exists. This phenomenon covers the fact that in light of low intensity the brightest portion of the solar spectrum is the yellow-green: whereas in daylight illumination the yellow portion of the spectrum is brightest. This shift in brightness value does not occur in the totally color-blind person, who reacts to the spectrum as to a series of shades of gray. (2) Trial may be made to force the animal to select a red as opposed to a given intensity of white light when the red is the darker of the two. When this habit is perfectly established, the brightness of the red is increased or the brightness of the white decreased. If no intensity of white, from black to pure white, is confused with red, the animal undoubtedly is responding to a difference in wave-length, or color. Using a method of this type with colored papers, DeVoss and Ganson have presented evidence indicating color blindness in cats. (3) In the third method two colors, e.g., red and green, may be presented to the animal as we have already described. If a discrimination is set up, the relative intensities, or brightnesses, can now be reversed. A persistence of successful choosing during this reversal would indicate color sensitivity. In making such a test our labor is much shortened and sometimes more fruitful if we know from prior tests how much it is necessary to change the relative intensities in order to reverse their values. There are many difficulties peculiar to the foregoing experiments, but they must be passed over.

Studies of Learning.—We must turn now from cases of sensory discrimination to problems of habit formation. Here we shall gain an insight into problems of behavior which will continue to concern us, in man, throughout the book. Earlier in the chapter we commented briefly upon the original modes of acting—instincts. Here, on the other hand, we are to consider certain phases of derived (habitual) behavior. The studies on habit-formation are studies of learning and forgetting. It is very important to know what the laws of learning are and how conditions may best be adapted to secure the highest efficiency. Is it more economical to give one trial a day, or two, or three? Should one learn a task in parts or should one learn it as a whole, if economy of effort is to be secured? Does learning ability vary with sex and age? Do habits interfere with each other, and can efficiency in one task improve ability in another (transfer of training)? How does loss of retention proceed? Is it most rapid at first and slower toward the last? These and many other problems of great practical value can be answered as well, if not better, by tests upon animals than by tests upon human subjects, for with animals we more readily control motives, prepossessions, and modes of living, and we also secure more convenient material.

In Figure 14 are summarized the data obtained by Ulrich (1915) with white rats tested to determine which favored economical learning the most—one, three, or five trials daily. The tests required the rat to lift a latch in order to enter a box and secure food. The rat was said to have learned the problem when it ran to the box and lifted the latch in a minimum time. From the curves, which record both the number of trials and the number of days required to perfect the habits under the several conditions, the general conclusion can be drawn that the less frequent the trials, the fewer trials, but the more days are required for learning. Which method is the more economical will depend upon the value one wishes more to conserve, time or trials.

A thorough study of this question of the distribution of effort reveals the great complexity of the factors which determine the

most efficient condition of work. Thus C. J. Warden (1923), who has investigated the problem using rats in a maze, points out that with any given habit to be formed two important aspects of the distribution must be considered: (*a*) the variation in the number of trials between the intervals of rest; and (*b*) the length of the intervals. A large number of combinations of "trials" and "rests" when examined reveals an optimum arrangement which will probably be different for each habit to be formed. For the maze which he used,

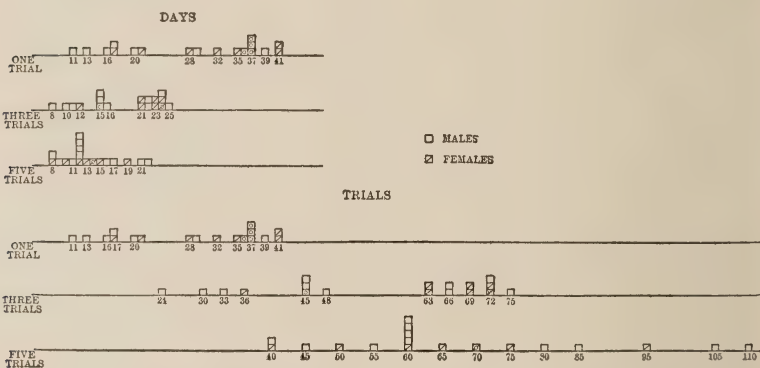


FIG. 14.—Results secured by Ulrich on the efficiency of distributed effort. The figure is further described in the text.

however, Warden found that a rest interval of 12 hours introduced either after one, three, or five trials was more efficient than intervals of 6 hours, 1, 3, or 5 days. He found, as did Ulrich, that one trial at a time was more advantageous than either three or five.[2]

Evidence that certain habits may aid or hinder the formation of other habits (cases of the transfer of training and of habit-interference) has been reported particularly by Hunter, Webb, and Wylie. The first investigator mentioned has shown that the formation of a given habit may interfere greatly with the formation of an opposite habit. Cases are also on record where transfer has occurred

[2] For a further discussion of economical learning, see chap. vi.

between visual and auditory habits, as opposed to transfer between two habits each aroused by vision or hearing. Other studies of habit-formation might be cited, but the foregoing will give a clear idea of the methods employed and the goals to be attained.

Imitation.—We turn now in the topic of "Imitation" and in the following one, of the "Delayed Reaction," to forms of acquired behavior which more nearly approximate the thinking behavior of man. We shall define imitation here in the simplest possible manner as the performance of an act by animal No. 1 by virtue of having been stimulated by the same act performed by animal No. 2. We shall discuss imitation at greater length in the chapter on "Social and Racial Anthroponomy," page 133. At the present point our intention is to illustrate the typical method of studying the problem experimentally, whether in man or animals.

Haggerty has made the most thorough test of the presence and nature of imitation in animals, using monkeys as subjects. Studies on imitation have also been made by Hobhouse, Thorndike, Berry, and Watson. The nature of Haggerty's method and results may be indicated in terms of the "rope problem" illustrated in Figure 15. In order to secure food the animal must climb up a rope, push open a small door while supporting himself on the rope, and finally reach through the door for food. Monkey No. 1 is placed in the apparatus and given an opportunity to learn the problem by himself. If he fails to do so the experimenter may help him so that finally the subject can make the response correctly without aid. Monkey No. 2 is now tested, and, let us assume, fails. No. 2 is now confined in a small cage within the larger one and in such a position that he can see monkey No. 1 solve the problem and get the food. If after witnessing this performance a certain number of times No. 2 is given a chance and succeeds (even after much effort), it is evident that No. 1's behavior has aided him. Does this result mean that imitation is present? No; not if by imitation it is meant that animal No. 2 *concludes* because No. 1 secured food in such and such a manner that therefore he, No. 2, can also. It does indicate that he has been stimulated when another member of his own species secures food,

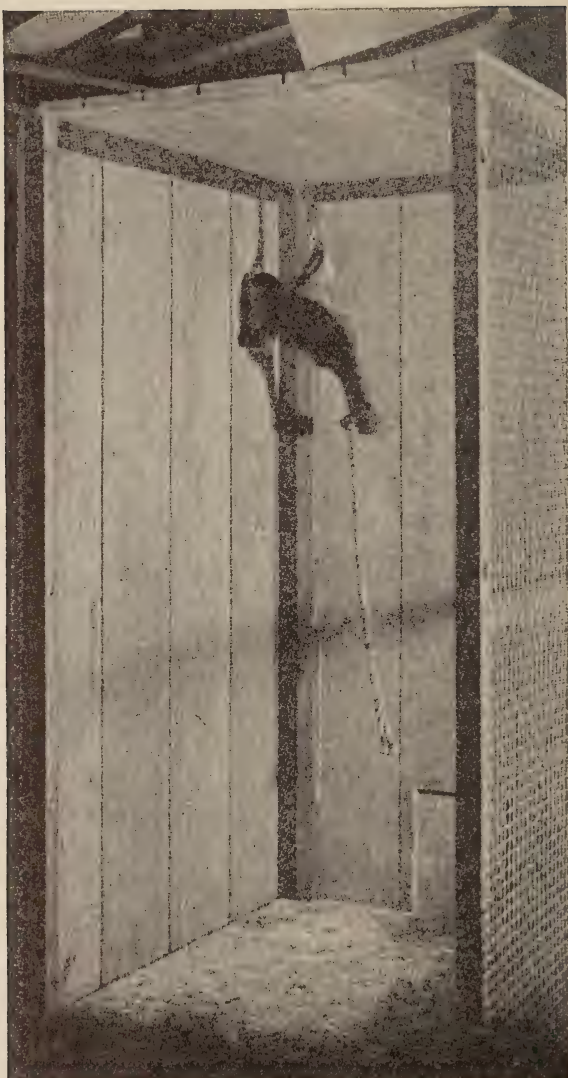


FIG. 15.—A monkey securing food after solving Haggerty's rope problem. A further account is given in the text.

and that when he himself is given an opportunity he goes to the place where food has appeared the time before. The influence exerted by the first monkey upon the second one was a social influence, a specific incentive to an increased activity which led to learning. There is no clear evidence that animals imitate as a result of language processes as man sometimes does. However, the facts are not entirely clear with respect to what man does in cases of imitation.

The Delayed Reaction.—The instances of animal behavior so far described are all cases of responses to present stimuli. A color, a sound, or a series of pathways is presented to the animal. Upon the basis of his ability to respond to these, we determine the stimuli to which he is sensitive. The delayed reaction, on the other hand, is a study of responses made when the stimuli are absent at the moment of response. A cat, for example, sees a mouse appear at a hole. The mouse disappears, and sooner or later the cat reaches the hole. The delayed reaction introduces, in addition to this element of delay between the disappearance of the stimulus and the beginning of the response, the element of selection. Let us suppose that there are three holes and that the mouse had appeared in each one an equal number of times. After the mouse has appeared and disappeared at one hole, could the cat pick out which hole to go to? If it could for a short interval of time, how much would this need to be increased before the limit of the cat's ability would be reached? And then, most important of all, what method did the animal use in solving the problem? The delayed reaction has been studied with rats, dogs, cats, raccoons, apes, and children.

In Figure 16 is shown the apparatus used with cats. It is in principle the same as the apparatus used in the problem with other animals. The method of procedure is as follows: an animal is placed in *R*, the release box; a light can be turned on in either of three boxes; the animal's exit from the apparatus is blocked save through the lighted box. When the animal is released it must learn always to go through the box which is lighted (or in which a noise is sounded, if sound is the stimulus) and return to *R*, where food is

given. When once the animal has perfected this association of light and food the real problem begins. The experimenter then places the animal in the release box; turns on the light in some one of the three boxes; when the animal has been stimulated by the light, turns it off; keeps the animal in the release box for a certain interval of time; and finally releases it. Will it go out the box that was most recently lighted? If this is the case, the period of delay is increased until the limit of the animal's ability is reached. The maximal intervals of successful delay obtained in this problem are as follows:

Rats	1–5 seconds
Raccoons	10–25 seconds
Cats	16–18 seconds
Dogs	1–3 minutes
Child 1¼ yrs.	20 seconds
Child 2½ yrs.	50 seconds
Child 5 yrs.	At least 20 minutes
Gorilla	2–3 hours

The essential characteristics of the delayed reaction problem are these: (1) A stimulus must be used which can be presented to the animal and then withdrawn during the interval of delay. (2) There must be no secondary stimulus left in the apparatus which could determine the animal's response. And (3) at least two possible exits, or forms of response, must be used in order that the factor of selection shall be involved.

The ability to respond correctly under the conditions of this experiment does not in itself constitute evidence that the animal possesses symbols. Rather, this evidence must be sought in the behavior of the animal during the delay. This behavior is more interesting than the length of time that an animal can successfully delay. (It must be remembered that there is nothing outside the animal's body to determine which box is correct.) The rats, cats, and dogs (Hunter and Yarbrough) had to keep their heads or bodies oriented toward the proper box if the correct reaction was to occur. Raccoons, dogs (according to Walton), apes (Yerkes), and children, however, could lose their orientations during the delay and still re-

act correctly. There was some process within their bodies which could be used to guide the proper response although the animals had not remained facing the proper box during the interval of delay. The hypothesis advanced in explanation is that this process, or cue, comes from the muscles of the animal and is kinaesthetic in kind. Its function is that of a *symbol,* because it enables the animal to react to an absent object in a selective manner, although it—the

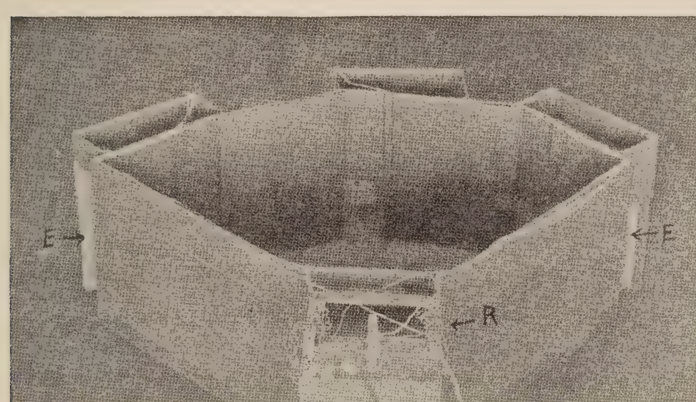


FIG. 16.—The delayed-reaction box (after Yarbrough). *R* is the release box in which the animal is detained during the interval of delay. An electric-light bulb is visible in the central box at the rear. The animal must escape from the apparatus through the exit *E* of one of these three boxes, each of which can be illuminated at will. The experimenter stands near *R*, separated from the apparatus by an opaque screen. This prevents the animal from catching cues from him.

cue—has not been continuously present. This means that *we define a symbol as any process which is a substitute, which can arouse a selective response, and which can be recalled if it ceases to be present.* Such processes occur but infrequently in animals below man. Their development in human subjects makes possible the growth of such fields of endeavor as morals, religion, and science, which help distinguish human behavior as more complex and varied than that of the beast.

Conclusion.—We have now canvassed typical problems and results from the field of animal behavior. We have seen enough of the methods to gain a fair insight into the methods of procedure and the safeguards, controls, that are employed. There are numerous problems, however, such as that of language capacities, which we have been unable to describe for lack of space, although they are of great importance in a comprehensive survey of the field. Our introductory discussion of this field leads us to see the importance of careful, objective methods in a field of behavior that is very concrete. It calls our attention to forms of behavior which are common to man and animals and also to forms that are strikingly different. The variations in the sensory and motor equipment of man and animals are the things that are termed variations in intelligence. An animal that can see more or hear more than another animal is to that extent the more intelligent of the two. So the animal that can adjust itself by muscular movements in the most varied ways is the most intelligent animal in that respect. This latter difference may occur between animals possessing the same sense organs and the same muscles. The difference is one that is determined within their nervous systems, for some nervous systems are inherently less plastic and adjustable than others. In the following chapter on "Individual and Applied Anthroponomy" we shall deal continually with questions concerning this general intelligence, or adjustability, in the human organism.

REFERENCES

Carr, H. A., and Watson, John B. "Orientation in the White Rat," *Jour. Comp. Neur. and Psych.*, XVIII (1908), 27–44.

Cason, Hulsey. "The Conditioned Pulpillary Reaction," *Jour. Exper. Psych.*, V (1922), 108–47.

Haggerty, M. E. "Imitation in Monkeys," *Jour. Comp. Neur. and Psych.*, XIX (1909), 337–455.

Hunter, W. S. "Delayed Reaction in Animals and Children," *Behav. Mon.*, II (1913), No. 6.

———. "The Delayed Reaction in a Child," *Psych. Rev.*, XXIV (1917), 74–87.

HUNTER, W. S. "The Auditory Sensitivity of the White Rat," *Jour. Animal Behavior,* IV (1914), 215–22; V (1915), 312–29.

JENNINGS, H. S. *The Behavior of Lower Organisms* (New York, 1906).

JOHNSON, H. M. "Audition and Habit Formation in the Dog," *Behavior Mon.,* Vol. II (1913), No. 8.

KÖHLER, W. *The Mentality of Apes* (New York, 1925).

LASHLEY, K. S. "The Color Vision of Birds. I. The Spectrum of the Domestic Fowl," *Jour. Animal Behavior,* VI (1916), 1–26.

———. "Studies of Cerebral Function in Learning," *Psychobiology,* II (1920), 55–135.

LIGGETT, J. R. "An Experimental Study of the Olfactory Sensitivity of the White Rat," *Genetic Psych. Mon.,* Vol. III (1928), No. 1.

McINDOO, N. E. "Smell and Taste and Their Applications," *Scientific Monthly* (1917), pp. 481–503.

PAVLOV, I. P. *Conditioned Reflexes.* Trans. by G. V. Anrep (Oxford, 1927).

RICHTER, C. P. "A Behavioristic Study of the Activity of the Rat," *Comp. Psych. Mon.,* Vol. I (1922), No. 2.

STONE, C. P. "Congenital Sexual Behavior of the Young Male Albino Rat," *Jour. Comp. Psych.,* II (1922), 95–153.

THORNDIKE, E. L. *Animal Intelligence* (New York, 1911).

ULRICH, J. L. "Distribution of Effort in Learning in the White Rat," *Behavior Mon.,* Vol. II (1915), No. 10.

WARDEN, C. J. "The Distribution of Practice in Animal Learning," *Comp. Psych. Mon.,* Vol. I (1923), No. 3.

WASHBURN, M. F. *The Animal Mind* (3d ed., New York, 1926).

WATSON, JOHN B. *Behavior* (New York, 1914).

WEBB, L. W. "Transfer of Training and Retroaction. A Comparative Study," *Psych. Mon.,* Vol. XXIV (1917), No. 3.

YERKES, R. M. "The Sense of Hearing in Frogs," *Jour. Comp. Neur. and Psych.,* XV (1905), 279–304.

———. "The Mind of a Gorilla," *Genetic Psych. Mon.,* Vol. II (1927), Nos. 1, 2, 6.

CHAPTER II

INDIVIDUAL AND APPLIED ANTHROPONOMY

I. INDIVIDUAL ANTHROPONOMY

Introduction.—One of the most striking characteristics of human nature is the fact of individual variation. Individuals differ in the structure of various portions of the body and in the behavior of these structures as well as in the behavior of the body as a whole. Wherever in the present book we discuss the factors which determine behavior, we are dealing with factors which admit of significant individual differences. The possibility of such variations is particularly great wherever learning, i.e., the past history of the organism's behavior, enters as a determinant of response. Even in the unlearned behavior equipment of the organism, individual variations occur. Thus all infants cry without previous learning, and yet they differ notoriously in the modes of crying. Inasmuch as the nervous impulses which directly initiate behavior arise from receptors, it is immediately suggested that many differences in behavior may be due to variations in receptor efficiencies. This suggestion has a solid foundation in fact. Receptors vary greatly from one individual to another in fineness and range of sensitivity. Tones which stimulate one person may be quite outside the range of effective stimuli for another. Differences between tones may be too slight to determine behavior for one subject but not for another. One person may be able to sort a pile of variously colored yarns into piles of the same color without serious error, while another subject of equal training and intelligence makes glaring mistakes. Normal color vision is indicated for the former subject, and some form of color blindness is undoubtedly present in the latter.

The most significant behavior problems in individual anthroponomy, however, are those which deal with ability to solve typical

difficulties in the environment. No one problem can be chosen in whose solution all persons will prove equally efficient, for they will distribute themselves through all the grades from very poor to excellent. The discovery and quantitative measurement of these variations in ability are of great importance, not only to the general science of human behavior, but also to medicine, law, industry, and the social sciences.

When we wish to secure a picture of an individual's behavior traits, two methods are available: (1) We may make an exhaustive inventory of each behavior trait, e.g., musical performance, the solution of arithmetical problems, and the giving of verbal opposites to verbal stimuli. Or (2) we may secure samples of the various traits and rate the subject in terms of what we have previously learned concerning the performance of many other subjects in these same samples. This later method is the one followed in the use of behavior tests popularly known as "mental tests." The method has a high dependability, and it is immensely more economical and practical than the former method.

Types of Behavior Tests.—There are three chief types of behavior tests devised for the measurement of three important aspects of behavior. These tests may be termed tests of *general intelligence, special ability,* and *present attainment.* Let us outline the three problems in that order. (1) Tests of general intelligence seek to give the individual his relative rank in the population with respect to his native learning capacity, i.e., his innate ability to adjust himself to new situations. Those who occupy the lowest level of ability are known as the feebleminded. Superior intelligence is at the other extreme, occupying the highest level of adaptive ability. These tests do not seek to measure such personality traits as initiative, leadership, and care for detail. This is a separate problem in whose formulation and solution behaviorists are just beginning. (2) Tests of special ability seek to rate individuals with reference to their unlearned capacities for specific performance. Seashore's tests of musical talent are the most highly developed ones in this group. We shall describe them very briefly later in the present chapter.

Work of this character offers the chief promise of a scientific vocational guidance. (3) Tests of present attainment rate individuals with reference to their skill in given lines of activity. The emphasis here is not upon the individual's capacity to become, let us say, an expert engineer or auto mechanic. These examinations ask only how much skill the individual now has. The chief scientific example of these methods is found in the *trade tests* developed in the United States Army under the direction of W. D. Scott. These were examinations standardized upon a nation-wide basis for classifying men as novices, apprentices, or experts in the skilled vocations required by the military organizations. Such a procedure was necessary if the right man was to be assigned to the right place. The greatest practical value of such tests in civilian life lies in their use by employers of skilled labor.

The Binet-Simon Scale.—The best-known and most widely used scale of behavior tests for general ability is the Binet-Simon scale, first published in 1905. This was devised by the French psychologist Alfred Binet in 1904 in response to the request that he survey the schools of Paris for the purpose of detecting feebleminded pupils. The scale as constructed was largely an elaboration and compilation of tests that Binet and his collaborator, Th. Simon, had already used for another purpose. The essential characteristics of the scale are as follows: (1) The establishment of the behavior age of a child is sought in terms of the average performance of other children of that age. (2) A group of four or five tests is provided for each age. (3) The ages provided for range from three to fifteen. In addition five tests for adults are given. (4) All of the tests require the understanding of language, and most of them require the subject to reply in terms of language. (5) Only one individual is examined at a time, the time required being from thirty minutes to an hour. A bare outline of the tests, as arranged by Binet in 1911, is as follows:[1]

[1] A. Binet and Th. Simon, *A Method of Measuring the Development of the Intelligence of Young Children.* Trans. by Town (Chicago, 1913), pp. 7–9.

THREE YEARS

Shows nose, eyes, and mouth.
Repeats two digits.
Enumerates objects in a picture.
Gives family name.
Repeats a sentence of six syllables.

FOUR YEARS

Gives own sex.
Names key, knife, and penny.
Repeats three digits.
Compares two lines.

FIVE YEARS

Compares two weights.
Copies a square.
Repeats a sentence of ten syllables.
Counts four pennies.
Plays game of patience with two pieces.

SIX YEARS

Distinguishes between morning and afternoon.
Defines in terms of use.
Copies a lozenge.
Counts thirteen pennies.
Compares faces from the aesthetic point of view.

SEVEN YEARS

Right hand; left ear.
Describes a picture.
Executes three commissions.
Gives value of 9 sous, 3 of which are double.
Names four colors.

EIGHT YEARS

Compares two remembered objects.
Counts from 20 to 0.
Indicates omissions in pictures.
Gives day and date.
Repeats five digits.

NINE YEARS

Gives change from 20 sous.
Defines in terms superior to use.
Recognizes all the pieces of our money.
Enumerates the months.
Understands easy questions.

TEN YEARS

Arranges five weights.
Copies drawings from memory.
Criticizes absurd statements.
Understands difficult questions.
Uses three given words in two sentences.

TWELVE YEARS

Resists suggestion (length of lines).
Composes one sentence containing three given words.
Says more than sixty words in three minutes.
Defines abstract terms.
Discovers the sense of a sentence the words of which are mixed.

FIFTEEN YEARS

Repeats seven digits.
Gives three rhymes.
Repeats a sentence of twenty-six syllables.
Interprets a picture.
Solves a problem from several facts.

ADULT

Solves the paper-cutting test.
Rearranges a triangle.
Gives differences in meaning of abstract terms.
Solves the question of the President.
Gives a résumé of the thought of Hervieu.

The calculation of the behavior age of an individual on the basis of the tests outlined is not a simple matter. The results secured are never so clear-cut as to make the determination automatic, for a child will pass all of the tests for a certain age and a scattered

number of tests for higher ages. Accordingly, in giving him his final ranking, one proceeds as follows: the highest age at which the child passes all tests is termed his base age; then for every additional five tests belonging to higher ages he is credited with one year in addition to his base age. A child is diagnosed as retarded if his behavior age is one or two years below his chronological age.

Criticisms of the Binet-Simon Scale.—The Binet scale established itself almost at once as the most reliable method of gauging general ability then in existence. Yet its use suggested many defects which led Binet himself to revise it. In this country revisions have been proposed, particularly by Kuhlmann, Goddard, Terman, and Yerkes. Of these the latter two have made the most significant changes. In general we may list the chief criticisms of the early scale as follows: (1) The tests for the early ages are too easy, and those for the upper ages are too difficult. Various other tests seem misplaced as to age. (2) The directions given for the application and grading of the tests are so general that confusion arises among different investigators. (3) The scale utilizes language ability to such an extent that it is inapplicable, particularly to speech defectives and to the deaf. Investigators have also found difficulty in adapting the scale to non-English-speaking subjects. (4) The method of determining behavior age is inadequate. The Terman, or Stanford, revision attempts particularly to remedy the first and second criticisms. It also meets the fourth by following the German psychologist Stern's method of calculating behavior age. In addition a more extended series of thoroughly tested and standardized tests for adults is offered. The Yerkes revision places chief emphasis upon criticisms 2 and 4. Criticism 3 cannot be met by a remodeling of the Binet scale, but a series of non-language tests must be devised and standardized. This task has been done most extensively by Pintner and Paterson (1917), and later by the army psychologists.

Performance Tests.—Let us first consider the scale of performance tests recommended by Pintner and Paterson, who were stimulated in their work by the necessity for testing deaf children.

The scale includes fifteen tests derived from various sources. Three of these tests we shall describe briefly. (1) The Seguin-Goddard form board (Fig. 17) has been extensively used by Sylvester upon children of various ages. The problem for the child is the laying of each block in its proper place in a minimal time with no errors. The time limit allowed for solution is five minutes. (2) The

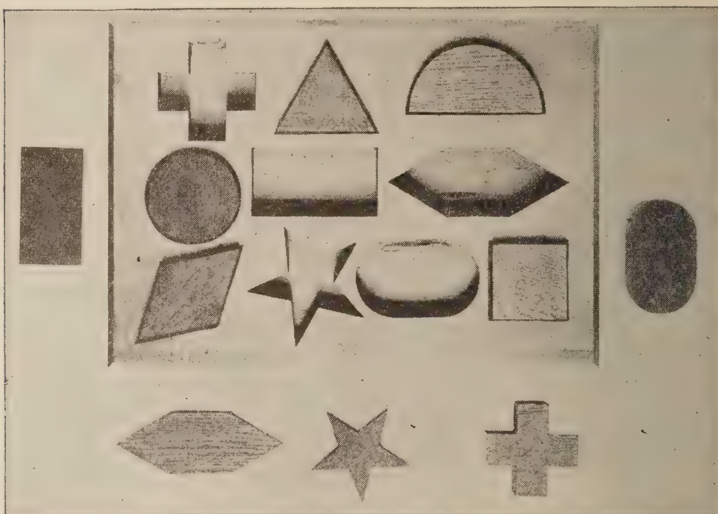


FIG. 17.—A typical form board

pictorial-completion test devised by Healy (Fig. 18) requires the child to complete the picture by the proper insertions of the cut-out portions. (3) The Knox cube test uses five small cubes. Four of these are placed in a row before the child and the fifth is held by the experimenter, who then taps the cubes with the one he holds. The number and the order of the taps may vary as follows: 1–2–3–4, 1–2–3–4–3, 1–3–2–4–3, etc. At the conclusion of one number the tapping cube is placed before the child, and he is told to tap likewise. A definite, invariable series of numbers is used with all subjects tested.

Pintner and Paterson, on the basis of extensive tests made by themselves and other research students, offer tables showing the

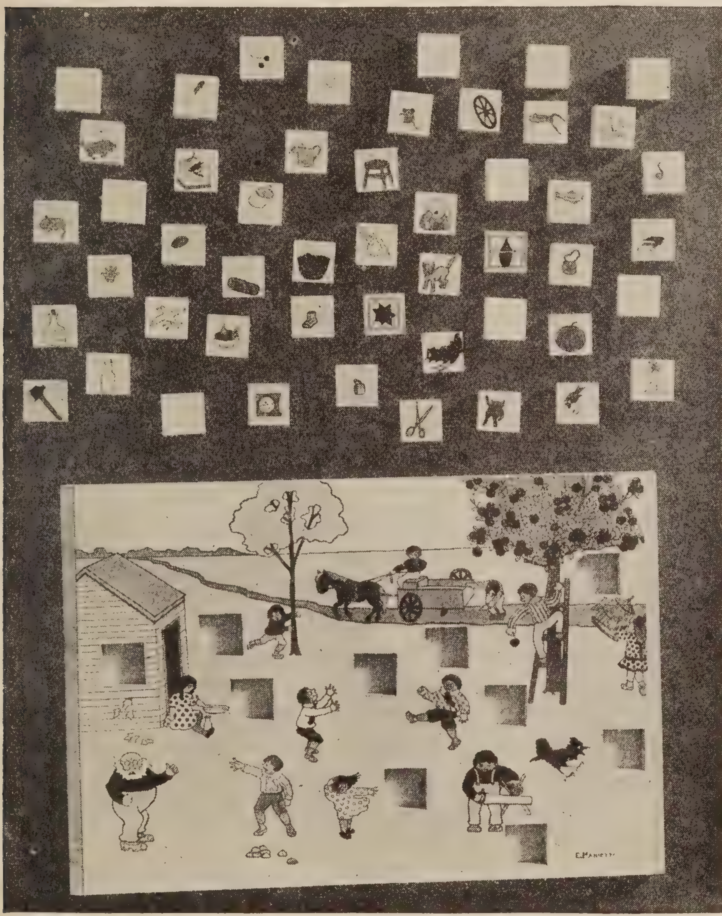


FIG. 18.—Healy's pictorial completion test

scores made at various ages. It is found that both the time consumed and the errors made in the test decrease with the increasing

age of the subject tested. In applying the scale to an individual child, the question of age credit comes up at once. For example, what score must a child make on a given test in order to pass as a six-year-old in that test? Credit is not given unless the child's record is as good as the lowest of the upper 75 per cent of the children tested at that age. Seven-year credit is given if the grade secured falls in a class with the upper 75 per cent of the children who are seven years old. In determining finally the behavior age of a child the procedure may be the same as in the Binet scale: that is, a basal age is determined at which the child passes all tests; then additional credit is given for higher tests that may be passed. The behavior age is the sum of the two.

The Calculation of Behavior Age.—Terman and Yerkes have been the chief critics of the Binet-Simon method of determining behavior age, which we have already presented in connection with the original scale and with the performance scale. Terman, following Stern suggests the use of an *intelligence quotient*. This combines two points made by Binet into a single expression: that is, in place of stating a behavior age (which Terman calculates on Binet's principle) and then stating its relation to the chronological age, Terman divides the former by the latter and terms the result the *intelligence quotient, IQ*. This method recognizes the fact that a retardation of one, two, or three years in an eight-year-old child is more serious than the same retardation in a twelve-year-old one. A child of eight years whose behavior age is eight has an *IQ* of 100. If the behavior age is 10, the *IQ* for the same child is 125. Terman's work upon 1,000 children represents the frequencies with which the various *IQ's* occur in the general population from which they were taken. He found that only 1 per cent equal or exceed an *IQ* of 130; that 5 per cent equal or exceed 122; that one-third equal or exceed 106; that one-third equal or go below 95; and that 1 per cent equal or go below 70. As a result of his experiments Terman classifies the grades of intelligence as follows:[2]

[2] L. M. Terman, *The Measurement of Intelligence* (Boston, 1916), p. 79.

IQ	Classification
Above 140	"Near" genius or genius
120–140	Very superior intelligence
110–120	Superior intelligence
90–110	Normal, or average, intelligence
80– 90	Dulness, rarely classifiable as feeblemindedness
70– 80	Borderline deficiency, sometimes classifiable as dulness, often as feeblemindedness
Below 70	Definite feeblemindedness

In the following section the nature of feeblemindedness will be discussed and illustrated. Here, in contrast, we shall cite one of Terman's cases of very superior intelligence. Notice should be given to the way in which the child's record bears out the *IQ*.

T. F. Boy, age 10–6; mental age 14; IQ, 133. At 13–6 tested at "superior adult," and had vocabulary of 13,000 (also "superior adult"). Son of a college professor. Did not go to school till age of 9 years and was not taught to read till 8½. At this writing he is 15½ years old and is a senior in high school. He will complete the high-school course in three and one-half years with A to B marks, mostly A. Gets his hardest mathematics lessons in five to ten minutes. Science is his play. When he discovered Hodge's *Nature Study and Life,* at age of 11 years, he literally slept with the book till he almost knew it by heart. Since age 12 he has given much time to magazines on mechanics and electricity. At 13 he installed a wireless apparatus without other aid than his electrical magazines. He has, for a boy of his age, a rather remarkable understanding of the principles underlying electrical applications. He is known by his playmates as "the boy with a hobby." Stamp collections, butterfly and moth collections (over 70 different varieties), seashore collections, and wireless apparatus all show that the appellation is fully merited. He chooses his hobbies and "rides" them entirely on his own initiative.[3]

Yerkes, in his criticism of the Binet method of calculating behavior age, suggests a point scale where the child's standing is given in terms of points and not in terms of years. A perfect score on the twenty tests (borrowed largely from those of Binet-Simon) of his

[3] *Ibid.,* p. 99.

scale is 100. One characteristic of merit in this system is the fact that in many tests partial credit is given for partial performance in a way not possible with the Binet system of grading. Data have been gathered with the point scale showing approximate normal scores for children of various ages. By comparison with these standards (which are always open to further extension and revision) it is possible to determine the rank of a given child relative to the average, or normal, score for his age. The individual score divided by the normal for that age gives the behavior level.

Group-Examination Methods.—The Binet-Simon scale and its modifications are essentially adapted to the testing of one individual at a time. Because of the length of time involved they are not therefore suited to the examination of large numbers of individuals, and yet this is practically necessary if one is to obtain a view of the intelligence of whole communities. Within recent years many test scales have been devised which can be given to a group of several hundred people at one time. Of these the Army Intelligence Tests[4] are the most widely known. Each individual is supplied with an examination test blank and the group is given a definite time-interval of one minute, five minutes, etc., during which to work on each test. The score is indicated by the relative amount of work accurately completed in the time allowed. By this means one can rapidly survey a school system, a community, or an organization and secure its relative intelligence-rating. The practical importance of such data is tremendous in its possibilities. Why are certain city neighborhoods less progressive than others? Why are certain sections of the country poorly developed? The answer may well be found, not in the physical advantages or disadvantages of the land, but in the behavior level of the population.

[4] This point-scale is composed of tests assembled and standardized by a committee of psychologists in 1917–18. It is difficult to give credit to individuals in this co-operative undertaking, but there will perhaps be no objection to the statement that the following men exerted a major influence: Yerkes, Thorndike, Terman, and Otis. The latter in particular contributed many features from a scale which has since been published.

The Standardization of Tests.—The reliability of a test rests upon its standardization. Reliability is not a characteristic which can be discovered by inspecting a test, except where the test is similar to others of known value. Questions and problems which seem to the layman extremely simple and even absurd may constitute the parts of a highly reliable measure of ability. The decision must always rest finally upon the excellence of the standardizing process through which the tests have passed. Let us, therefore, examine the procedure by which a test is devised and standardized. We shall consider for purposes of illustration the revision of the Binet-Simon tests made by Terman and the construction of the United States Army Intelligence Scale.

A. The Stanford Revision, prepared by Terman and his associates, involved the following steps: (1) Single tests were selected whose solution would involve various behavior capacities of the individual. (2) The tests were devised to involve a minimum of the informational material secured by formal schooling. (3) They were arranged in an approximate order of difficulty from those for very young children to those for adults. (4) These tests were then given to 1,698 typical school children and to 362 adults (each child was within two months of its birthday). A base age was determined and additional higher tests were given until the individual failed in all at some age level. (5) The records thus secured were then scored and the average behavior age so determined was compared with the physical age of the six-year-old children, the seven-year-olds, and so on. (6) In order that the average child should have an *IQ* of 100, the individual tests were: shifted in position in the scale, scored by a different method, rephrased, or dropped from the scale. (7) Performance upon each test was compared with performance on the scale as a whole. And (8) the *IQ's* of those tested were then compared with practical criteria of intelligence as found in teachers' estimates of ability and in school progress. The result is the Stanford Revision of the Binet-Simon tests.

B. The United States Army Intelligence Scale was standardized by the following procedure: (1) Ten tests were chosen which

were known to involve forms of behavior related to general intelligence. Each test included from ten to forty items arranged in order of difficulty. (2) Tentative time limits were set for each test and provisional methods of scoring were decided upon. (3) The scale was applied to a large group of soldiers. (4) The data so secured were then examined in order to determine what changes should be made in: the time allotted, the method of scoring, the composition of each test, and in the composition of the scale as a whole. (5) In solving these questions three chief scientific requirements were laid down: (*a*) the tests must be easy enough so that all persons could get a start and yet hard enough so that few if any could make a perfect score (stated more technically, the distribution of the individual scores must approximate a normal curve); (*b*) to a high degree each test must measure the same ability measured by the scale as a whole; and (*c*) the score on the scale as a whole must check up well with practical ability to adjust one's self in such a novel environment as that presented by military life. This scale so rigorously standardized had a very high reliability as a means of securing comparative ratings of groups of individuals with reference to their capacity to profit by training. It was not, and could not be, so reliable as an indicator of the ability of each individual of the group. Behavior tests are not infallible, but the evidence shows that they are the best methods known for making the desired estimates of ability.

The Feebleminded.—The scales for the measurement of an individual's relative ability are of fundamental psychological and sociological importance. We have just seen a suggestion of this in the account of group methods of examination. The group method is opening up a large field where the chief interest is in the relative ability of all persons in the population. The individual method of Binet has been chiefly interested in those of very inferior intelligence, the feebleminded. The average and superior individuals may be held back by adverse social conditions, but they will never seriously clog the machinery of progress with inefficiency and subnormal offspring. This is largely accomplished by the feebleminded.

As a result of the appreciation of this fact, the diagnosis of the mental status of the inmates of public institutions and of juvenile offenders is now an accepted and widespread procedure.

Estimates of the frequency of feeblemindedness among delinquents range from 25 per cent to 50 per cent. The frequency of feeblemindedness is not so great among the general population. Terman found, as indicated above, 1 per cent feebleminded in the 1,000 school children studied. The percentage in the general population, however, is probably higher because the school systems include only the higher grades of the feebleminded and the doubtful, or borderline, cases.

Three main grades of feeblemindedness are recognized: the idiot, the imbecile, and the moron. A conventional description given of their industrial capacities after complete development has occurred is as follows:

Behavior Age	Capacity and Adjustment	Grade or Direct
Less than 1	Helpless	Low idiot
1	Feeds self, eats everything	Middle idiot
2	Eats discriminately	High idiot
3	No work, plays little	Low imbecile
4	Tries to help	Middle imbecile
5	Only the simplest tasks	Middle imbecile
6	Tasks of short duration, washes dishes	Middle imbecile
7	Little errands in the house	High imbecile
8	Errands, light work, makes beds	Low moron
9	Heavier work, scrubs, mends	Middle moron
10	Good institution helpers; routine work	Middle moron
11	Fairly complicated work with only occasional oversight	Middle moron
12	Uses machinery; cares for animals; no supervision; cannot plan	High moron

The conditions just tabulated are generally regarded as incurable. In the training school at Vineland, New Jersey, Goddard has shown that feebleminded children who have reached their complete

development fail to improve when tested with the same scale year after year. The accompanying figure (Fig. 19) shows three types of feeblemindedness, all of which come from seriously defective ancestry. Although we cannot give a description of each case here, we shall comment briefly on that of Will T. His father was alcoholic and a sex offender. His mother, three of her brothers, two of her sisters, and her parents were feebleminded. His two brothers and four half-brothers were also subnormal. These facts point to the most serious question in relation to feeblemindedness, viz., the propagation of defective children who often become a social burden if not a social menace. The detection of these cases is one of the most important practical tasks of students of behavior.

The Inheritance of General Intelligence.—The tale of the inheritance of a low grade of general intelligence is ominous, and is only offset by the reflection that normal and high-grade ability must follow the same hereditary law. The possibility, furthermore, that feeblemindedness is recessive (Goddard) would make it less frequent in appearance in the general population. Goddard has published the most extensive studies of the inheritance of behavior defect. One of the most striking cases is that of the Kallikak family. The story is as follows: During the American Revolution, Martin Kallikak, a young man of good family, became the father of an illegitimate son. The child's mother was a feebleminded girl, and the boy, Martin, Jr., was like her. From this boy have come 480 descendants, practically all of whom have been feebleminded and criminalistic. One of the last of these is Deborah, a moron in the Vineland Training School. The story has another side, however. After the Revolution Martin married a normal girl, and from that union have come none but normal descendants, many of whom are of excellent ability. The two branches of the family live in the same section of the state, although they are in ignorance of their relationship. Indeed, in one instance a member of the abnormal line is in the employ of a descendant in the other line. Nothing could show more clearly than these two lines of descent the great hereditary importance of behavior defect.

FIG. 19.—Three feebleminded types (after Goddard): Will T. (upper), age 21, behavior age 8; Isaac Q., age 16, behavior age 10; Prudence Q., age 17, behavior age 3.

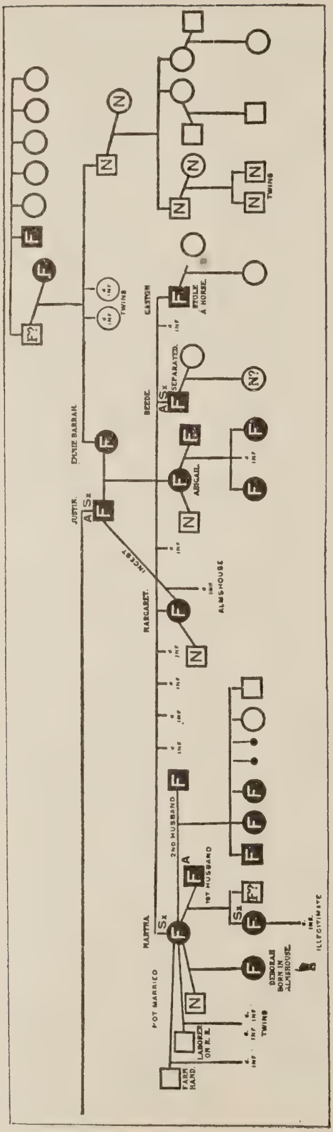


Fig. 20.—Deborah's ancestry as far back as her grandparents. The squares represent men; the circles, women. *F*, feeble-minded; *d. inf.*, died in infancy; *N*, normal; *Sx*, sex offender; *A*, alcoholic.

The reader should study carefully the accompanying chart, on which are presented a few of the details of this family. Of the 480 descendants of Martin, Jr., 143 were conclusively proved to be feebleminded, 36 were illegitimate, 41 were sexually immoral, 3 were criminals, 3 were epileptics, 24 were confirmed alcoholics, and 82 died in infancy. These individuals have in general married, and their mates were usually others of similar ability; accordingly, Goddard finally had on his charts 1,146 individuals. Figure 20 traces Deborah's ancestry in detail as far back as her grandparents. No greater argument for a prompt and serious consideration of eugenics could be offered than these records of the inheritance of defectiveness with its resulting crime, poverty, disease.

Additional evidence of importance supporting the belief that general intelligence is an inherited capacity will be presented in the discussion of behavior tests and racial differences, page 146.

Tests of Special Ability in Music.—Our account in this chapter has dealt largely with general intelligence tests. It remains now to describe briefly an outstanding test of special ability such as is found in Seashore's musical tests. Seashore has developed a series of measures of some of the fundamental capacities involved in musical talent (a list of these is given in Fig. 21). These tests seek to

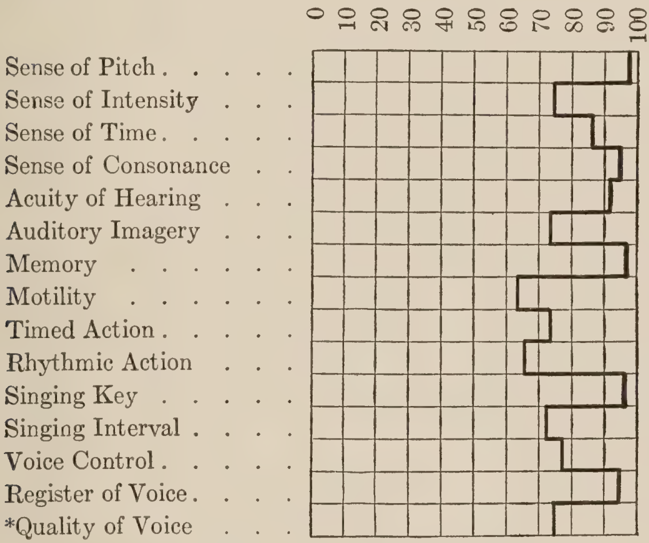


FIG. 21.—A musical profile for a talented subject (after Seashore). The capacities tested are listed on the left. The figures at the top indicate percentages. In the field of pitch, the subject ranked with the best 2 per cent of the population examined. In ability to discriminate intensities he was surpassed by 26 per cent of the population, and in memory for tones, by only 3 per cent. The remainder of the chart is to be read in like manner.

give the individual his relative rank in the population upon the basis of: his ability to distinguish small differences in the pitches of tones; his sensitivity to differences in sound intensities; his ability to indicate the tone which is different in such sequences as *do, me, sol* and *do, me la;* his ability to say which of two combinations of tones is the most harmonious; and other similar abilities. Experi-

ment shows a close relationship between ability in the tests and strength or weakness in musical performance (Gaw). Upon the basis of this examination very valuable vocational and avocational advice can be given looking toward the proper training of the individual. Here as elsewhere with tests, however, the complete diagnosis of the individual's capacity and talent does not rest upon the the test results alone. Such factors as physical attractiveness, perseverance, ambition, and early history must also be taken into account in securing the total picture of the subject's possibilities.

After a given individual has been rated in the various capacities his record may be put into the form of a *profile* as indicated in Figure 21. This figure represents an individual of high average talent. In all tests he ranks with the best 40 per cent of all who have been examined; while in six cases he belongs to the best 10 per cent of the group. The individual whose musical profile is here given is one who has shown much interest in music although he has had little formal training. Even more highly talented profiles than this one have been found for children who have had no musical training whatsoever and whose capacities might well have been overlooked without these tests.

The Use of Statistical Methods.—The discussion must now turn from results back to methods. Individual psychology has made a more extensive and significant use of statistical method than any other field of the science. This condition has grown out of the dominating position occupied in the field by the behavior tests which we have described. These tests, as our exposition has already brought out, aim at placing a given individual in his relative place in the population according to his ability in specific capacities and general adjustments. In order to do this it is necessary first to establish normal, or mean, records for the population concerned. The next step involves determining whether or not the norm is probably the true one for the group examined. There will be a certain amount of variation in the values secured for each mean when different classes of people or different conditions come into the experiment. It then becomes important to determine whether or not these

differences are significant. Suppose, for example, that *A* has made a large series of tests on children five years old, and has found that the average, or mean, score is 10 points. He now tests another group of children of the same age and secures a mean of 12 points. Is this an accidental and insignificant difference in results, or does it indicate the presence of disturbing factors in the experiment? Mathematical formulas have been worked out by means of which this question can be settled. The same question must be asked when tests are made at different ages in pursuit of age differences in performance. Let us assume that there is a difference in the average scores for a group of children five years old and a group who are six. Is this a significant and therefore an age difference, or is it insignificant? Again, the before-mentioned formulas are used to measure the probable error of the difference of the two means. Unless the numerical difference exceeds the probable error at least four times, the difference can hardly be held as significant. The illustration that we have used concerns the effect of age on the average score for a certain test. In like manner one must deal with the effects of any one of many other possible factors that may affect the results.

Correlation.—In addition to these data it is often very important to know how an individual's rank in one test compares with his rank in another. Is a tall person also in general a heavy one? Is one who ranks high in mathematics also of excellent ability in science? To the extent that abilities, tendencies, or processes vary directly one with another, to that extent do we tend to credit them with a causal relationship (see page 339). This is *positive* correlation. *Negative* cases of correlation are those that vary inversely. Mathematical ability may always be great in those of poor literary ability, and vice versa. In this case one would speak of antagonistic causes at work. Instances of *indifferent* correlations are those where excellence in one field may or may not be accompanied by ability in another field. The relationship is one of chance. It is possible with problems of correlation to use mathematical formulas for determining the relationships involved, and in many cases this determination is absolutely necessary if obscure relationships are to

be detected. The method of correlation has the further value of aiding in the determination of exactly what is meant by such terms as general intelligence. Thus, if one test or scale, x, is known to correlate highly with intelligence, as the term is popularly understood, other tests or scales which correlate highly with x will also correlate highly with intelligence. And so one can gradually discover the ways in which intelligence acts. In standardizing tests, correlation is furthermore of particular value in checking up the test with

TABLE IV

Subject	Correlation by the Foot-Rule Method				
	I. Score in Arithmetical Test	II. Score in Behavior Test	Rank in I	Rank in II	Gain in Rank
1	20	190	3	2	1.
2	21	180	2	3	....
3	18	160	4	4	....
4	7	90	16	16.5	....
5	12	122	10	12.5	....
6	11	122	11	12.5	....
7	10	118	12.5	15	....
8	5	73	18	18	....
9	10	146	12.5	7	5.5
10	9	135	14	10	4.
11	13	149	9	6	3.
12	17	159	5	5	....
13	6	90	17	16.5	.5
14	4	62	19	19	....
15	8	120	15	14	1.
16	22	201	1	1	....
17	16	140	6	8	....
18	14	123	8	11	....
19	3	52	20	20	....
20	15	137	7	9	....

$N=20$ $\qquad R=1-\frac{6\Sigma g}{n^2-1}$ $\qquad \Sigma g=15.0$

$$=1-\frac{90}{399} \qquad \text{P.E.}_R=\frac{0.43}{\sqrt{n}}=0.09$$

$$=+.77$$

the practical situation. Do the men who stand high or low in the tests also rank correspondingly in their duties as policemen, as

salesmen, as students, etc.? The answer to this question is the final criterion of a test's (or of a scale of tests') specific validity.

Let us illustrate the method of correlation in terms of one of the simpler methods. Table IV gives the scores made by each of twenty individuals in an arithmetical test and in a general behavior test. If we now apply Spearman's Foot-Rule Method, it is possible to determine the degree to which ability in arithmetic varies with the general level of behavior. Spearman's formula is:

$$R = I - \frac{6\Sigma g}{n^2 - 1}$$

R is the coefficient of correlation; Σg, the sum of the gains in rank; and *n*, the number of cases. An examination of the procedure in the table will make the application of the formula clear. The individuals are first ranked in order of excellence in the arithmetic test from 1 to 20, dividing the rank values in case of tie. The same thing is then done for the scores. All gains in rank are then determined and totaled. Substitution in the formula gives *R* a value of +.77, indicating a high positive relationship between the two tests. The probable error of the correlation is given by the formula $\text{P.E.}_R = \frac{0.43}{\sqrt{n}}$. Unless *R* is at least four times its P.E., no particular value attaches to it, and it is said to be unreliable. When *R* is negative, the correlation is inverse but *R's* true value must be determined by re-ranking one series of measurements in the opposite direction.

II. APPLIED ANTHROPONOMY

It is difficult to draw distinctions between applied anthroponomy and any of the other fields included in the present book. The term makes an unwarranted division between the science of behavior and the applications of this knowledge to some practical end. An adequate understanding of human nature involves the accept-

ance and use of both points of view. When we approach the study of the abnormal, the social, the animal, etc., we apply all the information that is at our command in reaching an understanding of the problem. Likewise in the analysis of the normal adult individual one applies all of the information available in order to solve that question. Inasmuch, however, as the term "applied science" is in general use, we may employ it to cover certain comments upon the relations of the science of behavior to medicine, law, education, and business.

Anthroponomy in Its Relation to Medicine and Law.—The science of behavior and medicine come closest together in the topics we shall discuss in the following chapter on "Abnormal Behavior." The physician will be helped, to be sure, by a general understanding of the basic facts of human nature. His chief help, however, in the treatment of behavior disorders will come from an understanding and appreciation of the following two points:

1. He should be familiar with the methods used by behaviorists in testing the various sense organs. This is no simple matter. It is a field for specialization in itself, for there are specific precautions to be taken in the study of color blindness, in the diagnosis of defects in touch, etc. The chief interest in this topic finally centers upon the study of injuries to the nervous system with their accompanying behavior defects. Medical men themselves have made the chief contributions to these investigations. It is safe to say, however, that it is only when their data and methods are put in relation to those of anthroponomy that the full significance of their contributions is caught.

2. The second aid which the science of behavior offers medicine lies in the analysis of the hidden forces of human character. Sigmund Freud has studied in great detail the bits of behavior that become forgotten or eliminated under the stress of emotion. These the average student has regarded as of no further influence upon conduct. Freud, however, has claimed, and has presented much evidence to show, that these repressed complexes do continue to influence behavior. From time to time in certain individuals they reap-

pear and distort behavior, and in this way produce the characteristic symptoms of many behavior disorders. In less serious form they crop out in the dreams, wit, lapses of speech, etc., of the "normal" individual. We shall discuss this fascinating topic briefly in the next chapter, and at that time the present comments should be recalled. It may well be insisted here, however, as it was before, that this semimedical field lacks breadth and sane perspective when it is isolated from the data on human nature presented in general anthroponomy.

The contributions of anthroponomy to law are much more one-sided. To understand law in its broad significance one must appreciate the nature of society and of those forces which govern the interaction of men. Much of this material can be secured only in the study of social behavior, which we are to review briefly in chapter iv. Mention may be made, however, of two ways in which scientific data have been applied to the problems of the courts.

1. An effort has been made to secure criteria of valid testimony and to measure the variations in testimony under different conditions. Subjects are shown pictures or events, e.g., for a brief interval of time and are then requested to give a report of what they have seen. Even where the results do no more than confirm what one's experience would lead him to expect, they are illuminating in pointing out the complexity of the testimony situation. It is found particularly that children and abnormal adults do not testify accurately; that accuracy and quantity of testimony are to some extent in inverse ratio; that the form of the interrogation used in cross-examination has a great effect upon the evidence given; and that what a witness discriminates depends markedly upon his condition at that time. Further comments will be made in Part II, chapter vi, in the account of the correlation of stimulus and response.

2. At the present time the most valuable aid that the science of behavior can offer law is in the diagnosis of the general intelligence of offenders. Although it is of great importance, we need not dwell upon this topic. The foregoing discussion of individual an-

throponomy has presented the methods of diagnosis used and the hereditary evils necessary to be combated. Various courts and institutions have already seen the necessity of arriving at an understanding of their wards before assessing punishment or planning reform. Much of this understanding can come through the proper use of behavior tests; much, however, must come from the type of diagnosis of the individual's total behavior organization which the psychiatrist is skilled in giving.

We spoke before of the estimates concerning the relation between delinquency and behavior deficiency. The present topic should not be closed without a brief reference to Murchison's work on the application of behavior tests to individuals confined in American prisons. In general Murchison finds that the level of ability of prisoners is quite as high as that of the general public, when this is judged in terms of the scores made on behavior tests by the United States Army draft. The inference to which such work seems to point is that criminality is due to some character twist rather than to a defect in those forms of ability measured in the tests.

The Relation of Anthroponomy to Education.—The process of educating an individual is the process of adjusting him to his environmental problems. One may thus term the whole of the science of behavior "educational anthroponomy." The careful student of education should be intimately familiar with the topic of instincts because they are the fundamentals upon which all modifications by experience must rest. He should be thoroughly acquainted furthermore with the facts of learning. Finally, in particular there should be a sympathetic understanding of the field of general and special ability tests. Much of the valuable material in these topics owes its discovery to the urgency of pedagogical demand and to the enthusiasm of students of education. These problems are certain portions of the general field of human nature which, without the aid of men primarily interested in educational problems, would have been developed neither so rapidly nor so soon as they have been. *Educational anthroponomy,* however, as a special field, deals with human nature so far as schoolroom conditions may make it peculiar

or so far as unique adjustments may there be required of it. The principles of learning and habit-formation in general, e.g., are topics for inclusion in this field only so far as school children learn under peculiar conditions. Typical important problems are these: What is the proper length of the recitation period? What learning processes are peculiarly involved in arithmetic, in spelling, in geography, etc.? How shall one grade or estimate ability in the various lines of training? What are the factors determining an individual's progress in the curriculum? To what extent are entrance examinations indicative of the future relative ranking of individuals? To what extent can one's ability in higher grades be predicted from his rank in lower grades? These and a host of other similar problems are being attacked and solved. The field of behavior tests has an extension here in the scales devised for the grading of special school abilities such as arithmetic, writing, and language. Yeoman's work has also been done in making intensive studies of the mechanics of reading and writing—two habits of fundamental importance in the educational scheme. Instruction and training in these professional problems are supplanting the earlier work, the attitude of which was that educational anthroponomy consisted in general anthroponomy plus a few more or less obvious applications to schoolroom conditions.

The Science of Behavior in Business.—The study and analysis of business problems from the behavioristic standpoint are increasing rapidly. The interest and the confidence of many large corporations assure the successful continuance of this work. Space limits our comments to a few illustrative cases only. Most firms that employ many men find at the close of a month, six months, or a year, numerous misfits who must either be dismissed or transferred to other branches of the business, where the trial continues. This constant turnover of employees means a great sacrifice for the firm in time, money, and efficiency. It is possible to devise tests to be applied to seekers of employment which will eliminate much of this waste. These tests are so arranged that they involve the habits and capacities required in a particular trade, such as telephone

work, salesmanship, expert gunner's work, etc. Each of these series of tests, in order to be rated as valid, must detect the salesmen, e.g., whom the firm has already found to be the most successful and also those who have proved to be the least so. No test or scale of tests can go back of this criterion of validity. The behaviorist makes no effort to go behind the firm's own experience concerning the men who have proved most successful in their work; but he uses the rating of these men on his tests in improving and standardizing his scale. Such a general procedure is a vast improvement over the present methods because it enables the employer to determine in a short time and at a minimum cost that which at present he can learn only after employing a man for a period of months or years.

As an example of the procedure we can give the test applied to telephone girls by Münsterberg. The problem was to devise tests which would detect those girls who held out promise of being successful in their work. Thirty women were used, among whom, unknown to Münsterberg, were some highly efficient operators placed there by the company. Sample tests used were as follows: (1) The auditory memory span was determined. This is the greatest number of digits that one can write down after having heard them slowly pronounced once. Numbers ranging from four digits to twelve digits were used. (2) Efficiency of work was measured by requiring the subjects to cancel out each *a* on a newspaper page. Six minutes were allowed and grades or scores were given on the basis of the amount and quality of work. (3) Space discrimination and the ability to make rapid accurate movements were tested. (4) Each girl was required to sort rapidly a complicated series of cards. The girls were ranked according to their ability in these and similar tests, and after three months these results were *correlated* with the experience of the telephone company. It was found that the subjects who ranked high in the actual telephone work also ranked high in the tests.

A. J. Snow has developed a series of tests for automobile drivers which has been of great practical value in the selection of taxicab drivers. The series consists of the following eight tests: (1) Physical examination. (2) General behavior tests of intelligence.

(3) Emotional stability: "The theory underlying this test is based upon an analogy drawn from the actual operation of a transportation vehicle. In this test, as in controlling the movements of a vehicle (the pilot's attention being held by the usual operation of the vehicle), the attention of the subject is held by his attempt to light the bulbs on the apparatus as directed. Then suddenly an emergency is created which emotionally disturbs the subject and to which he must react successfully." (4) Recklessness: "This test consists of a board on which are four lanes. The careful driver will select the lane which permits him to make the best time with the least number of 'accidents' and will also slow down considerably the movement of the stylus as he approaches and passes any points of difficulty found in his path." This test is illustrated in Figure 22. (5) Muscular fatigue. (6) Muscular resistance. (7) Reaction times. And (8) reaction to space and motion: "Mounted upon a board 20 feet long are two toy vehicles whose motion is controlled by a system of pulleys and weights. There is a fixed scale of numbers 3 inches apart along the tracks. The subject stands 15 feet from the apparatus, facing it. The vehicles are moved at different speeds in different directions, according to eight different prearranged combinations. The subject is asked at a given signal to indicate at what point the two cars will pass or overtake one another. The experimenter records the error between the subject's estimate and the actual point of passing."

Business is interested not only in the employment of individuals capable as operators, clerks, salesmen, etc., but it is interested in sales brought about through the medium of advertising. An advertisement is a stimulus to response and is therefore subject to careful behavioristic analysis. Experimentation along this line has been well begun by such investigators as Scott, Strong, Hollingworth, Adams, Kitson, and others. Of the many problems available for study we may list the following: What is the effect on the selling power of the advertisement of the following factors: (*a*) the location on the page; (*b*) the frequency of its appearance; (*c*) the

character of the type; (*d*) the character of the illustrations; (*e*) the colors employed; (*f*) the various types of descriptive reading, etc.? In performing these experiments suitable advertisements are used in such a manner that as nearly as possible only one factor shall be tested at a time. The selling power is measured under laboratory conditions in terms of what the subjects say concerning the

FIG. 22.—The recklessness test used by Snow

appeal made by the various cases and in terms of what recall tests show of the different degrees to which the retention of advertisement is affected by the factors concerned. Data so secured from a large number of observers can be of great economic value in business. To be of the greatest value, however, the results so secured should be checked up by actual selling returns for the different ad-

vertisements. In some cases this has been possible, and the outcome has held out encouragement for further study.

Conclusion.—The goal of individual anthroponomy is the construction of a profile representing the individual's rank in the sum total of traits revealed in behavior. The great outstanding contribution made by this field of study is this: *Measures of sample performances in the human individual can be secured which have predictive value for the complex behavior of daily life.* The sample performance is a response to those stimuli involved in the test, while everyday behavior includes a great variety of responses to a large diversity of stimuli. The underlying capacities, general intelligence or special ability (or both), which shape the outline of the one also make possible the characteristic features of the other.

The present chapter, in addition to emphasizing the variations in human nature, has pointed out many of the practical applications of the science of human behavior. And yet it must not be assumed that these applications are limited to tests and related procedures. Our next study will be of the individual from the view point of his abnormal behavior, the field where anthroponomy and medicine come most closely together. Throughout the book, practical possibilities for the science will be evident to those who are interested in them.

REFERENCES

Burt, Cyril. *The Young Delinquent* (New York, 1925).
Burtt, H. E. *Employment Psychology* (Boston, 1926).
Gesell, A. *The Mental Growth of the Preschool Child* (New York, 1925).
Goddard, H. H. *The Kallikak Family* (New York, 1912).
Gorphe, F. *La Critique du Témoinage* (2d ed., Paris, 1927).
Kenagy, H. G., and Yoakum, C. S. *The Selection and Training of Salesmen* (New York, 1925).
Kitson, H. D. *The Mind of the Buyer* (New York, 1921).
Kingsbury, F. A., and Crennan, C. H. (editors). "Psychology in Business," *Annals Amer. Acad. Polit. and Soc. Science,* Vol. CX (1923), No. 199.
Murchison, C. *Criminal Intelligence* (Worcester, Massachusetts, 1926).

PINTNER, R. *Intelligence Testing* (New York, 1923).

PINTNER, R., AND PATERSON, D. G. *A Scale of Performance Tests* (New York, 1917).

POFFENBERGER, A. T. *Applied Psychology* (New York, 1927).

SCOTT, W. D. *The Psychology of Advertising* (3d ed., Boston, 1912).

SEASHORE, C. E. *Psychology of Musical Talent* (Boston, 1919).

SNOW, A. J. "Tests for Transportation Pilots," *Jour. Applied Psych.*, X (1926), 37–51.

———. "It Will Take More than Education to Stem Traffic Accidents," *Indust. Psych. Monthly,* II (1927), 360–64.

TERMAN, L. M. *The Measurement of Intelligence* (Boston, 1916).

———, AND OTHERS. *Genetic Studies of Genius.* Vol. I, *Mental and Physical Traits of 1,000 Gifted Children* (Stanford University, 1925).

THORNDIKE, E. L., AND OTHERS. *The Measurement of Intelligence* (New York, 1927).

TREDGOLD, A. F. *Mental Deficiency (Amentia)* (3d ed., New York, 1920).

WHIPPLE, G. M. *Manual of Mental and Physical Tests.* 2 vols. (Baltimore, 1915).

YERKES, R. M., BRIDGES, J. W., AND HARDWICK, ROSE S. *A Point Scale for Measuring Mental Ability* (Baltimore, 1915).

YERKES, R. M. (editor). "Psychological Examining in the United States Army," *Nat. Acad. Science Memoirs,* XV (1921), 1–890.

CHAPTER III

ABNORMAL BEHAVIOR

Introduction.—The field of abnormal behavior has long included a list of more or less unrelated problems, the claim for treatment of many of which lay in their unusual and mystic character. Here would belong particularly telepathy and spiritualism. Other problems, however, dealing with nervous disease, abnormal behavior, and the analysis of the less obvious aspects of human nature rightly hold the positions of chief importance in the field. Here one finds a body of topics involving a growing accumulation of solid fact which is intimately bound up with social and individual welfare and with an adequate conception of the range and quality of human behavior. The problems especially involved are those of multiple personality, hysteria, certain insanities, the inheritance of behavior defects, dreams, and psychoanalysis. This is the series of topics from which we shall select in our attempt to formulate a picture of human nature as it deviates markedly from the normal in the direction of disease. The present chapter, accordingly, is closely related to the preceding one where we discussed, among other topics, the problem of subnormal behavior. The dominant principle in the phenomena now to be studied is that of the disintegration of a co-ordinated behavior into mal-co-ordinated groups of responses. Since all behavior is controlled through the nervous system, the explanation of this disintegration lies partly in some dissociation of the nervous processes concerned. Such an explanation, however, in order to be adequate must be supplemented with an account which traces the history, or genesis, of the disorder in the individual's life-history. The most striking examples of dissociation are the scientific cases which are similar to the story of Dr. Jekyll and Mr. Hyde. Later in the discussion we shall have occasion to analyze these in detail.

The human individual is judged normal in virtue of his ability to adjust himself with average success to his environment. When we speak of behavior disorders we refer to chronic cases of maladjustment to the environment. In many instances definite defects (lesions due to tumors, accidents, and disease) can be found in the nervous system which can be correlated with the disturbance according to the principle of cause and effect. These are the *structural neuroses*. *Functional neuroses* do not reveal an accompanying nervous defect. There is good reason for assuming its presence, however, and for attributing our inability to detect it to our present inadequate methods of search. As examples of the structural neuroses, we may think of cases of *general paresis*, whose cause is a syphilitic infection and subsequent destruction of brain tissue. This is the great outstanding structural neurosis, and we shall have occasion later in the chapter to describe both its behavioristic and physical sides. Most of our study, however, will concern the functional neuroses. It is here that we come closest to the average daily behavior of normal human beings. Here we find hysteria, paranoia, dementia praecox, and other disturbances. Less abnormal are dreams, morbid fears, and the many cases of slips of speech and forgetting that insistently appear in daily life.

Defense Mechanisms.—The transition from the normal to the abnormal is very gradual and may well engage our attention through a discussion of defense mechanisms. It may be stated as a universal principle that each individual is in constant conflict with other individuals and with various parts of his own individuality. He is a constant applicant for the approbation of others, for their respect, and for superiority over them. Furthermore, he must retain respect for himself. His life must be valuable in his own eyes. Any of his own personal or social behavior that tends to interfere with the foregoing behavior will probably arouse fear, shame, remorse, regret, and other similar emotions. Such situations tend to be avoided by one means or another. The simple organism may leave an environment that is too hot or cold and so defend itself. Likewise, man may leave the society of other persons who refuse to

look upon him with favor. In these social cases, however, where other selves are involved, not only is the individual haunted by the recall of past disapprovals, but he has also thrust himself into another social group where the same situation will probably be repeated. He cannot avoid his fellows entirely any more than he can fly from himself and his own disturbing fears and reproaches.

In these cases where flight from conflict is useless or impossible an individual constructs more or less intentionally a system of defense mechanisms which serves to eliminate the recall of the disturbing behavior. These defenses may take the form of elaborately thought out systems of symbols. One may find, e.g., a case where an individual, in order to avoid admitting his own incompetence, builds up the delusion of being persecuted by all whom he meets. He cannot hold his job. He goes from one field of employment to another, constantly driven—so he makes himself believe—not by his own shortcomings but by the envy and persecution of his associates. Systems of philosophy, while they are much more valuable socially than systems of delusions of the type just indicated, are also shelters from the storms of conflict with an unfriendly world. The Stoics and Epicureans of the Greek and Roman age sought consolation and dignity in such a world when the real world seemed prone to fall to pieces about their ears. Similarly, the child who is shy and non-self-asserting may build up a mythical world of companions where he goes for play and comradeship. It is no rare thing for such a "defense" to last over into adult life. Furthermore, beautiful women and large robust men who may feel their own shortcomings fall back upon poses and domineering attitudes as defense mechanisms for their self-esteem. Comfortable people, who should have economized as a patriotic duty during the Great War and who would have been ashamed to be unpatriotic, shielded themselves behind many excuses in order to gratify their desires. Thus, the theater became necessary to maintain their spiritual morale; their automobiles must not depreciate from rust as gasoline mounted in price; and as for expensive dishes, "Why, one must not let the caterer starve, poor man!"

In the realm of disease, unreal pains appear which serve to ward off the undesirable. Backaches and headaches, pains in the eyes and elsewhere, keep the willing patient from his task. "The further advanced neurotic who already spends life in bed and thinks it monotonous to be alone gets peculiar attacks in which, for example, he rushes to the window and tries to throw himself out; these attacks necessitate the continual presence of a nurse, in spite of the fact that the family can little afford the luxury. A poor woman who suffers from her insignificant position in life, often, when she comes to any new place, has a habit of attempting suicide, so that everyone is frightened and she is thus made a topic of general conversation, as if she were some great celebrity—so for a time she is assured against the pangs of obscurity."[1]

Opposed to these more highly elaborated defense mechanisms is the simple one of forgetting. The behavior which, if recalled, would cause distress or would arouse shame, remorse, lack of self-esteem, etc., drops from the individual's possible forms of behavior in accordance with an unformulated wish to be free from it. The recognition of this fact clears up many errors in daily life and many of the strange amnesias (instances of forgetting) in behavior. Father constantly forgets to pay the bill for mother's hat. He may attempt to use his office key in the home door, having forgotten where he is in accordance with his wish to be back at the office. One may persistently insult an acquaintance by forgetting his name, thus indicating that he is of little importance. Likewise in the field of dreams the illustrations are legion. Painful incidents tend to be forgotten, and the individual is thus saved from shame, horror, and the like. In the field of abnormal behavior, the interpretation and the analysis of amnesias are particularly important. We shall discuss these cases under the topic of hysteria.

One further "normal" case may be cited by way of pointing out the mechanism of these instances of forgetting. In the lectures on a course in behavior, it was my custom to describe a certain experiment performed on the brain of a man who was not anaesthe-

[1] P. Bjerre, *History and Practice of Psychanalysis* (Boston, 1916), p. 141.

tized. The surgeon's name was X. One session when the lecture was being given it was found that the name X was completely forgotten. In analyzing this unusual case of amnesia first one associated response and then another occurred, until suddenly the name of Y appeared. The explanation was then clear. Y was a close friend whose child had been suspected of being hydrocephalous. This was very distressing both to the parents and to the circle of friends. This fact I had repressed and forgotten. Y took the child to X for diagnosis, and so X became associated for me with the occurrence and was repressed and forgotten also. Even after this analysis I could not recall X's name.

The concept of defense mechanisms owes much to Adler, who has shown the intimate connection between "organ inferiority" and the development of personality. The child or adult person who finds himself neglected, or ugly, or unloved, and consequently inferior, builds up a compensation in behavior. He seeks refuge possibly by constructing an ideal world where he is not neglected or ugly, or he may remind himself of his own intellectual superiority or of the goodness of his deeds. Likewise, one whose vision is defective may compensate for the fact by an acquired delicacy of touch or hearing. One who fears his lungs are weak may develop many behavior peculiarities growing out of a solicitous attitude toward his respiratory apparatus, and he may, indeed, in combating his inferiority, develop a powerful physique. Defense mechanisms as described in this section afford the explanatory cue to many characteristics of the functional disorders to be described below.

Delusions and Hallucinations.—Even a casual observation of subjects who manifest marked abnormalities of behavior or of subjects who are temporarily abnormal, as in sleep, reveals the striking phenomena which have been termed hallucinatory and delusional behavior. The subject behaves *as if* something were happening which cannot be verified by the observers. This *"as if"* behavior may be of any degree of similarity to the behavior usually manifested when the event reacted to is present. I may respond exactly as though my name were called and I were given that auditory

stimulus, i.e., I may run or weep as I have done at times in the past when my name was called. Or my overt, gross behavior may be partially or completely arrested by other stimuli (the obvious absence of any person who might call), and partial responses alone may be present. In this case verbal behavior only may occur, verbal behavior of the kind I have been taught to make when people stimulate me auditorily by saying, "Did you hear that?" Such an isolated case of abnormality is referred to as hallucinatory behavior. In delusional behavior the subject's responses are organized *as if* he were persecuted or *as if* he were loved. These peculiar systems of response persist although impartial observers can find no justification in the environing conditions for such behavior. Such an abnormal organization of behavior may persist for days or years and pervert the entire life of the subject.

Types of Behavior Abnormalities.—Just as it is impossible to separate sharply normal from abnormal behavior, so it is impossible to draw any fixed lines between the different types within the field of abnormal behavior itself. Descriptively the best one can do is to enumerate certain broad characteristics that appear to dominate in the more fundamental disorders. Therapeutically one must take each case on its own merits and deal with behavior abnormalities in protean form. We may, however, follow Jelliffe and White (1915) in listing the chief disorders: hysteria, compulsion neurosis, anxiety neurosis, neurasthenia, manic-depressive psychoses; paranoia; epilepsy, dementia praecox, behavior disorders due to infection, exhaustion, or poison; disorders associated with such diseases as apoplexy, heart disease, chorea, etc.; and presenile, and arteriosclerotic disorders. To these we shall add paresis. Jelliffe and White also add the subnormal behavior of idiots, imbeciles, and morons, and we may recognize that these topics concern the field of abnormal behavior as well as that of individual differences. It is permissible, however, to separate the last three cases of subnormal behavior from the disorders previously listed for the following reason: In idiots, imbeciles, and morons one deals with individuals who have failed to develop normal capacities of adjustment. In the

other defects the individuals are suffering from a loss of capacities which they once enjoyed. Obviously we shall be unable to deal even by definition with all the forms of abnormality just listed. We shall accordingly seek a view of abnormal human nature through the study of a few only of its manifestations.

Causes of Behavior Abnormalities.—The causes of behavior abnormalities are legion. Whatever interferes with the normal functioning of the nervous system produces disorders in behavior. In such a list one may place: alcoholism; infectious diseases, e.g., scarlet fever, diphtheria, tuberculosis, and particularly syphilis; poisonings incident to certain occupations, e.g., lead and mercury poisonings; moral shocks; excessive fatigue; accidents, e.g., falls and wounds; etc. Individuals vary greatly in their resistance to such disturbing factors. What will produce delirium, hallucinatory behavior, paranoia, or dementia in one person may leave another quite unaffected. The strain of nursing a parent through a fatal illness may produce hysteria in one person and only temporary exhaustion and distress in another. Syphilitic infection in one person may result in tabes, paresis, or other defect, and in another the infection may never manifest itself in the realm of behavior disorder. This lack of resistance may be termed an instability of nervous organization, and is probably inherited.

The importance of physical and social heredity as a determining factor in any given case of behavior disorder can hardly be overestimated. We have already stressed physical heredity in the case of the Kallikak family, which was presented in the foregoing chapter. This inheritance rests upon variations in the germ plasm of the individual, and is not a social inheritance in the sense that the contents of education are. The social conditions surrounding the individual will determine largely the detailed nature of his disordered behavior. They will determine the nature of his delusional responses, or they will even shift the behavior from one of hysteria to one of paranoia or dementia praecox, but underlying the total phenomenon will still be the presumably inherited weakness of neural organization. As yet, however, we know too little of the ex-

tent to which parental influence may distort the behavior of the child after it is born to be dogmatic on the existence of the inherited weakness. We cannot be sure that the mother's anxieties and delusional behavior, e.g., may not themselves have distorted the behavior of some of her children to such an extent that they too develop the same or other disorders. Such a process would account for much of the abnormality which runs in certain families, and it even leads us to caution in interpreting the rôle of physical heredity in such case histories as the Kallikak family presents.

Paresis.—From the large field of behavior disorders we shall select four topics: paresis, paranoia, multiple personality, and hysteria. A brief presentation of these will give us much information concerning the abnormal phases of human nature. Let us first consider paresis.

Paresis, or *progressive general paralysis,* is a disturbance of behavior correlated with a certain type of cerebral syphilis. There is not so much a paralysis here as there is a general weakness. On the behavior side progression is made in various typical ways to a final loss of ability to care even for one's simplest needs. This gradual change may extend over a period of from one to five years. It is practically uniformly fatal. Apparent recoveries or remissions are usual, only however to be followed by a relapse and a fatal termination. Most frequently the disease appears in middle life, although juvenile paresis is also found. Figure 23 shows a lateral view of the brain with widespread destruction of its surface in paresis.

Quotation may be made from Church and Peterson (1908) in description of the early symptoms:[2]

General paresis is one of the most insidious forms of insanity as regards its gradual, almost unnoticeable onset. Very often this early stage presents symptoms which lead to its being mistaken for neurasthenia. Indeed, the earliest symptoms may be neurasthenic in character, or even a combination of hysteria with neurasthenia. Sleeplessness, tremor, irritability of mood, hypochondriacal depression, dull headache, ophthalmic

[2] A. Church and F. Peterson, *Nervous and Mental Diseases* (Philadelphia, 1908), p. 832.

migraine, pains in various parts of the body, general malaise, loss of appetite, and digestive disorders—these are the manifestations which may be readily misinterpreted as purely of functional nature. It is only when other symptoms in addition to these are presented that a suspicion of a more serious malady may be entertained or the diagnosis actually established. These symptoms are, on the mental side: little faults of memory; errors in speech or writing; the misuse of words; the leaving out

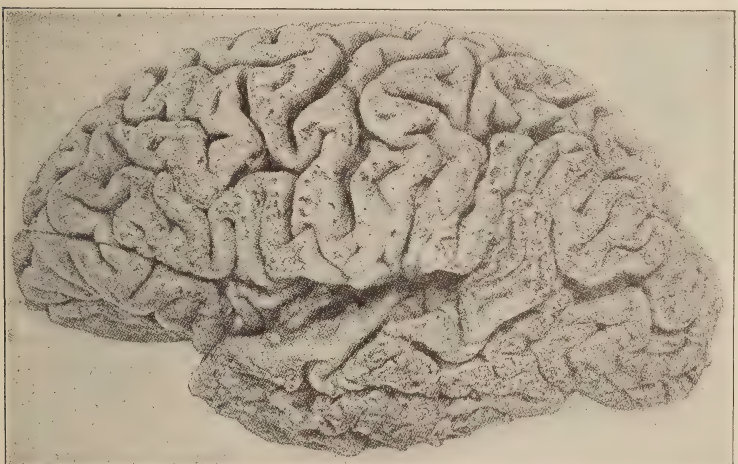


FIG. 23.—A lateral view of the brain in paresis (after Jelliffe and White)

of letters, syllables, or words, or their reduplication in writing; growing indifference to the higher sentiments; loss of the critical faculty; small lapses in the proprieties, and failure of interest in the more important affairs of life. As these mental features become more and more pronounced, the patient loses and mislays things, makes mistakes in money matters, errs in appointments, confuses persons and objects, forgets his way, becomes easily angered, markedly offends the proprieties, shows extravagance in the use of money, evinces distinct loss of ethical feelings, exhibits proclivities to sexual and alcoholic excess, and becomes negligent of his dress.

After this initial, or *prodromal,* period the foregoing symptoms increase in intensity. Amnesias (memory losses) become greater.

Grandiose or depressed delusions become more striking; excesses, more frequent and serious. On the bodily side many disturbances appear of which the following are typical: muscle tremors, particularly in the tongue and face; speech defects leading to a "drunken speech"; failure of the pupils of the eyes to contract to an increase in light intensity (Argyll-Robertson pupils); epileptiform or apoplectiform convulsions; and disorders of the hair, skin, and bone (trophic disorders). In the final stages the behavior disorganization becomes more and more profound, physical helplessness is usually complete, and death follows.

Paranoia.—Paranoia presents a very different picture from that just drawn for paresis, which is a structural disease. No changes can be found in the nervous system with which to correlate paranoia. It is therefore a functional disorder. The heredity of paranoid patients shows marked neuropathic (abnormal nervous) tendencies. The disease itself may be characterized as one of chronic systematized delusional behavior. Loss of ability to think and to care for one's self is not usual until the later stages of the disease. It is very doubtful whether cures are possible, and usually confinement in an institution is required, depending, however, upon the nature and severity of the disturbance. Many of the "cranks" and "peculiar" people that one constantly meets either are suffering from paranoia or are what may be termed *paranoid characters*. People who have had a single fixed type of behavior largely elaborated, who have regarded themselves as persecuted and as set apart from their fellows in ability and character, are paranoiacs. In this group can be found many leaders who have won distinction in war, politics, and religion. The treatment of the disorder consists in change of scene, hard outdoor work, and general diversion.

Krafft-Ebing subdivides paranoia, as it appears after adolescence, into the following types on the basis of the nature of the delusional behavior:

A. Paranoia persecutoria:
   a) the typical form,
   b) *paranoia erotica,* where the delusions are those of love and consist

largely in acting as though others were in love with the patient and were persecuting him,

c) *paranoia querulans,* or the type that is always engaging in lawsuits and quarrels.

B. Paranoia expansiva:

a) *paranoia inventoria* and *reformatoria,*

b) *paranoia religiosa,*

c) *paranoia erotica* in expansive form.

There seems to be good reason to believe that the systematized disorders of paranoia are defense mechanisms. Here, e.g., is a person who drifts from one job to another, failing at first from inability. Rather than admit his own inferiority, he begins to note seemingly suspicious behavior among his associates. They are spying upon him. They are carrying tales. They tamper with his work. Perhaps he reports the matter to his employer. Finally he is dismissed, and then he repeats the behavior in other situations. People soon begin to notice his peculiar actions, and this increases his persecutory delusions. Because his pains are many, he must have many enemies. Indeed, he is pursued by organized bands and groups. He may now hit upon the suggestion that the persecution results from his own great superiority—his associates are jealous of his skill. He is a Messiah, or the world's greatest soldier, or inventor, or what not. His manly characteristics are such that he is passionately loved by a beautiful lady whom his enemies prevent from coming to him—endless indeed is the variety of delusional behavior that the paranoiac may manifest. Commonly he behaves as though he were stimulated by sounds and sights which are not really present. The patient's enemies talk about him maliciously even at night when he tries to sleep. He reacts as to their voices although his persecutors remain unseen. The paranoiac may or may not react to his fancied persecutions in a way dangerous to himself or others, and a final stage of total behavior disorganization may or may not close the chapter of his life.

Multiple Personality.—The study of multiple personality offers another example of functional neuroses. The behavior of the

average individual is quite thoroughly organized so that no serious conflicts actually make of him two distinct behavior types. He retains the major portion of the actions which he performs. He has organized his behavior to such an extent that no strangeness attaches to the fact that his actions on the baseball field are governed by different standards from those which control his conduct in business or in the home. Yet in a very true sense it can be said that even though this individual's behavior is the possession of a single person, just as truly it may be regarded as belonging to three persons—a baseball self, a business self, and a home self. This view is justified by the fact of the three different standards of conduct which are used and by the fact of the very different factors which control the behavior of each self. It sometimes happens that the separation between the selves becomes so great that when one self is dominant the other selves not only do not, but really cannot, exercise any influence upon it. Even if these selves do modify the dominant one, they are so different from the one dominant at the time that no question is raised by the individual whether or not there is really more than one self involved. Stevenson's story of Dr. Jekyll and Mr. Hyde is a well-known instance. A few people are met in daily life who approximate this condition, and the annals of science contain many demonstrated cases.

Multiple personality, as we have said, *is a functional* disorder. It is closely related to hysteria, and is regarded by the eminent French investigator, Pierre Janet, as identical with that form of behavior. Like paranoia, these disorders are striking reminders of salient features in everyday normal life. An American scholar, Morton Prince, has written (1905) a very fascinating account of a Miss Beauchamp,[3] who came under his care and who finally proved to be a composite of four different personalities. All four of these selves, of course, were systems of behavior in the same body, but each must be regarded as employing a different organization of processes within the brain. In the following quotations we shall

[3] Morton Prince, *The Dissociation of a Personality* (New York, 1905).

present some of the chief characteristics of this most interesting case.

It was said in the beginning that, in addition to her normal self, and the hypnotic state known as B II, Miss Beauchamp may be any one of three different persons, who are known respectively as B I, B III, and B IV. . . . . The numbers were affixed to the personalities as they were chronologically discovered. That is to say, when Miss Beauchamp first came under observation she was known of course by her own name. Later, when she was hypnotized, her mental state in hypnosis was known as the hypnotic self. Everything was then simple enough, for we had to do only with a person awake and hypnotized, and no extended nomenclature was required. Later, when another mental state was discovered, it became necessary to have distinguishing terms; so Miss Beauchamp was called B I, the hypnotic state B II, and the third state (at first thought to be a second hypnotic state, but later proved to be a personality) was named B III. Still later, a fourth state developed and was termed B IV.

B I was known as Miss Beauchamp.

B III was known as "Chris," in distinction from "Christine," the Christian name of Miss Beauchamp. Later, Chris took the name of Sally.

B IV had no other name, although Sally dubbed her "the Idiot."

Now these three personalities had very sharply defined traits which gave a very distinctive individuality to each. One might say that each represented certain characteristic elements of human nature, and that the three might serve as an allegorical picture of the tendencies of man. If this were not a serious psychological study, I might feel temped to entitle this volume "The Saint, the Woman, and the Devil." The Saint, the typical saint of literature, is B I. Her character may fairly be said without exaggeration to personify those traits which expounders of various religions, whether Christian, Buddhist, Shinto, or Confucian, have held up as the ideals to be attained by human nature. To her mind selfishness, impatience, rudeness, uncharitableness, a failure to tell the truth or a suppression of half the truth were literally sins, and their manifestation wickedness, to be cast out by fasting, vigils, and prayer. She frequently makes allusion to such sins in her letters. B IV is the Woman, personifying the frailties of temper, self-concentration, ambition, and self-interest, which ordinarily are the dominating factors of the average human being. Her idea in life is to accomplish her own ends, regardless of the conse-

quences to others, and of the means employed. Sally is the Devil, not an immoral devil, to be sure, but rather a mischievous imp, one of that kind which we might imagine would take pleasure in thwarting the aspirations of humanity. To her pranks were largely due the moral suffering which B I endured, the social difficulties which befell B IV, and the trials and tribulations which were the lot of both.

Not the least interesting of the curious nervous phenomena manifested are the different degrees of health enjoyed by the different personalities. One would imagine that if ill health were always based on physical alterations, each personality must have the same ailments: but such is not the case. The person known as B I has the poorest health; B IV is more robust, and is capable of mental and physical exertion without ill effects, which would be beyond the powers of B I; while B III is a stranger to an ache or pain. She does not know what illness means.

This personality, Sally, like the others at times is an alternating personality. But, besides this, at other times it is a group of dissociated conscious states, which, existing simultaneously with the primary self, whether B I or B IV, is technically termed a subconsciousness—a subconscious personality. This subconscious personality and the waking personality together represent a doubling of the mind. But this doubling exists because certain mental states have been dissociated from the main stream of consciousness and have acquired a more or less independent existence, and form an *extra* mind. As a result of long years of experience, the acquisition of long chains of memories, this second stream has acquired a wide field of mental life. Nothing of this life is known to the main stream of consciousness.[4]

These four selves had a curious relationship one to the other. B I knew only herself. B II knew herself and also B I, i.e., in reality knew the actual thoughts of B I without being told. B III knew herself and each of the first two. B IV knew only herself and was only known to B III through her actions. When we speak of B I's not knowing the other selves, we are pointing out remarkable instances of amnesia, or forgetting. All of these selves exist in the same body, but when B I, for example, is uppermost the other selves are forgotten and are absent. From the standpoint of changes in behavior, they are non-existent. They persist only as changes of

[4] Morton Prince, *op. cit.*, pp. 15–18.

the brain, i.e., as behavior possibilities. B III, however, can report her own behavior and the actions of B I. Without making quotations one can readily understand how at a loss and even how embarrassed B I might be by the situations into which B III might lead her. Particularly must this be the case since B III is the mischievous imp that she is.

We have not space to follow the history of this case through its many windings to the final discovery by Dr. Prince of who the *real* Miss Beauchamp was. We must be content with the final outcomes. B II was the real girl, only asleep (hypnotized). B I and B IV were the disintegrations of B II. Sally (B III) was an alternating personality to the real Miss Beauchamp. With the latter's final constant existence Sally disappeared. A description of B II can be given best in the words of Dr. Prince:

> [B II] was a person so different from B I and B IV, so natural and self-contained, and so free from every sign of abnormality that there could be no doubt that I had again the Real Miss Beauchamp. There was none of the suffering, depression, and submissive idealism of B I; none of the ill-temper, stubbornness, and reticent antagonism of B IV. Nor was there any "rattling" of the mind, hallucinations, amnesia, bewilderment, or ignorance of events, as had been the case in the earlier experiments. She knew me and her surroundings and everything belonging to the lives of B I and B IV. She had the memories of both.[5]

Hysteria.—Since the extended case history which we have just given is in reality one of hysteria, our present account may be brief. Janet and Freud are the chief authorities on this defect. The former has contributed particularly to the descriptive analysis, and the latter to the explanatory analysis of the problem. We shall first summarize the topic as Janet views it.

Hysteria is characterized by great suggestibility, resulting in a tendency toward the breaking away from the system of unified behavior of specific forms of response. We saw the dissociation on a grand scale in the case of Miss Beauchamp. It may, however, be of any magnitude. It may merely take the form of slight recurrent

[5] *Ibid.*, pp. 519–20.

muscular twitchings (*tics*) either in isolated muscles or in the hands, shoulders, etc.; of somnambulisms; of hysterical fits and seizures; or of long flights (*fugues*) which may suddenly take the patient from his work and result in his waking from the trance in some distant locality without being able to say how he came there. Furthermore, this dissociation may be either positive or negative in its expression. Novel movements, as just described, may occur, or the effect may be a *paralysis*. Likewise in the realm of receptor processes the hysterical person may not only hear or see, strange things, i.e., have hallucinatory behavior, but he may be insensitive when he is touched (anaesthesia), or when objects are presented to his other receptors. These paralyses and anaesthesias are the result of suggestion and may appear suddenly. They do not depend upon an injury to the body. They probably arise when certain nervous processes become separated from others and yet continue to function as though normal. A patient, for example, may encounter the suggestion that she cannot move her leg or that her foot is insensitive, and immediately the suggestion becomes a reality, i.e., she becomes either paralyzed or anaesthetic, and the defective behavior becomes a part of her daily responses. In the Middle Ages anaesthetic areas of this type were well known and were regarded as indications that the person was a witch or was possessed of devils. As we know, a conventional method of "witch discovery" was to explore the subject's skin with a needle for insensitive spots.

In concluding the descriptive illustrations of the splitting off of isolated responses or of systems of responses, let us give a case in Janet's own words:

> We come back to the common story of a young girl twenty years old, called Irene, whom despair, caused by her mother's death, has made ill. We must remember that this woman's death has been very moving and dramatic. The poor woman, who had reached the last stage of consumption, lived alone with her daughter in a poor garret. Death came slowly, with suffocation, blood-vomiting, and all its frightful procession of symptoms. The girl struggled hopelessly against the impossible. She watched her mother during sixty nights, working at her sewing-machine to earn a few pennies necessary to sustain their lives. After the mother's

death she tried to revive the corpse, to call the breath back again; then, as she put the limbs upright, the body fell to the floor, and it took infinite exertion to lift it again into the bed. You may picture to yourself all that frightful scene. Some time after the funeral, curious and impressive symptoms began. It was one of the most splendid cases of somnambulism I ever saw.

The crises last for hours, and they show a splendid dramatic performance, for no actress could rehearse those lugubrious scenes with such perfection. The young girl has the singular habit of acting again all the events that took place at her mother's death, without forgetting the least detail. Sometimes she only speaks, relating all that happened with great volubility, putting questions and answers in turn, or asking questions only, and seeming to listen for the answer: sometimes she only sees the sight, looking with frightened face and staring on the various scenes, and acting according to what she sees. At other times she combines all hallucinations, words, and acts, and seems to play a very singular drama. When, in her drama, death has taken place, she carries on the same idea, and makes everything ready for her own suicide. She discusses it aloud, seems to speak with her mother, to receive advice from her; she fancies she will try to be run over by a locomotive. That detail is also a recollection of a real event of her life. She fancies she is on the way, and stretches herself out on the floor of the room, waiting for death, with mingled dread and impatience. She poses, and wears on her face expressions really worthy of admiration, which remain fixed during several minutes. The train arrives before her staring eyes, she utters a terrible shriek, and falls back motionless, as if she were dead. She soon gets up and begins acting over again one of the preceding scenes. In fact, one of the characteristics of these somnambulisms is that they repeat themselves indefinitely. Not only the different attacks are always exactly alike, repeating the same movements, expressions, and words, but in the course of the same attack, when it has lasted a certain time, the same scene may be repeated again exactly in the same way five or ten times. At last the agitation seems to wear out, the dream grows less clear, and gradually or suddenly, according to the cases, the patient comes back to her normal consciousness, takes up her ordinary business, quite undisturbed by what has happened.[6]

[6] P. Janet, *The Major Symptoms of Hysteria* (New York, 1907), pp. 29–31.

When this return of the normal state has occurred there is a complete amnesia for what has taken place during the seizure. Here we see again the same characteristics of divided personality that impressed us in the case of Miss Beauchamp.

Freud's conception of hysteria (dating from the initial study with Breuer in 1895), as we have said, is an explanatory one. The main question is, "Why should the amnesias exist?" for amnesias are the dividing lines for whatever dissociations there are within the individual. Freud answers this question with the concept of defense mechanism whose nature we have already sketched. Each individual is the scene for conflicts between fundamental tendencies. Each system of responses tends to inhibit those that conflict with it. Thus in the hysterical case we have just described, the young girl "forgot" her experience in nursing her mother as a defense against maladjustment. From time to time, however, this repressed behavior material would be re-aroused and would undergo what Freud terms *conversion* into the physical symptoms of the hysterical seizure. Freud would further insist that if the *psychoanalytic method*, soon to be described, were applied to each case of hysteria, the results would indicate two additional characteristics: first, the presence of infantile behavior material (reminiscences from the patient's childhood), and second, a close relation to behavior belonging to the sex life of the patient.

James, in his discussion of personality, has well described the conditions which arise because of the subject's disposition to pursue mutually incompatible systems of behavior. James says:

I am often confronted by the necessity of standing by one of my empirical selves and relinquishing the rest. Not that I would not, if I could, be both handsome and fat and well dressed, and a great athlete, and make a million a year, be a wit, a *bon-vivant*, and a lady-killer, as well as a philosopher; a philanthropist, statesman, warrior, and African explorer, as well as a "tone-poet" and saint. But the thing is simply impossible. The millionaire's work would run counter to the saint's; the *bon-vivant* and the philanthropist would trip each other up; the philosopher and the lady-killer could not well keep house in the same tenement

of clay. Such different characters may conceivably at the outset of life be alike *possible* to a man. But to make any one of them actual, the rest must more or less be suppressed.[7]

These competitions between the selves of a given individual contain the great dangers of behavior maladjustments as well as the possibilities of growth in behavior. Social conditions, as we have seen, require the repression of certain possible selves. Too often this has meant an attempt to distort essential human nature. In those who fail to work out a *modus vivendi,* who are unable to adjust their impulses to social demands without doing themselves violence, disorders of behavior appear. The individuals become the neurotic, the hysterical, the obsessed.

Freud's Conception of the Neuroses.—With the conclusion of our sketch of multiple personality and hysteria we are brought back to the topic of defense mechanisms with which the present chapter opened. The last section has familiarized us already to a certain extent with Freud's views on behavior disorder. We may now list the factors upon which he places emphasis in the explanation of these disorders as follows: (1) the repression (the elimination and therefore the forgetting) of any responses that would lead to a conflict with accepted modes of conduct; (2) the inhibiting activity of these conventional forms of conduct in the rôle of a censor; (3) the dominant place of sexuality, interpreted in its broadest significance, in the production of behavior disorders; and (4) the probability that the suppressed complexes, or the inhibited emotional behavior, in modified form will still continue to affect the total behavior of the individual whenever the censor can be eluded.

The Verbal Response Method of Analysis.—The sum total of overt and concealed, implicit, behavior which makes up the daily life of an individual constitutes his total personality. These forms of behavior are what they are in virtue of the thousand and one incidents through which the individual has passed since infancy. Undoubtedly if we had a complete and detailed description of the in-

[7] William James, *op. cit.,* I, 309–10.

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dividual's equipment at birth and an equally satisfactory record of the modifications of his responses since that time, we would be in a position to give a satisfactory explanation of his adult personality. Such a record we do not have. We have only occasional anecdotes concerning childhood behavior furnished us by relatives or friends of the individual in whom we are interested. We know that a child who has been badly frightened in an automobile accident may for years manifest slightly peculiar behavior. We know that children who have had their fear behavior conditioned by the dark may retain traces of this conditioning well into adult life. But when any specific case of abnormal adult behavior confronts us we lack the detailed case history upon which alone an explanation could be based (see 192 for a report of studies on the modification of fear).

The verbal-response method of analysis (popularly known as the method of psychoanalysis), which was devised by Freud and his colleagues, offers us the only practical avenue of approach to the history of many behavior disorders. This method depends upon the assumption that significant forms of behavior become connected with verbal responses and that through the re-arousal of the verbal responses some clue may be secured concerning the character of the original behavior. The method makes use of the fact that any responses which occur together may become associated in such a way that when one is re-aroused the other will probably appear also. Thus if a subject says "cat," the verbal response "dog" will probably follow by virtue of past training. The verbal-response method of analysis of a subject's past behavior history requires the subject to make audible to the examiner every word-response that is aroused in the subject during the examination. In order to eliminate distraction as much as possible the subject is placed in a reclining position and is instructed to take a passive, non-resisting attitude, permitting verbal responses to come as they will. Many of the verbal responses elicited will arouse emotional disturbances in the subject. Accordingly, the subject must be told explicitly that all responses aroused must be made audibly and without reserve,

else the search for the hidden determinants of his behavior cannot proceed. It can be readily seen that in the hands of a skilful examiner this method is certain to arouse verbal responses connected with behavior which occurred long ago and much of which has seldom been reinstated. Unfortunately the examiner must depend upon his own ingenuity and good judgment in determining the significance of the subject's responses inasmuch as he does not have the complete case history to which we referred previously. Most of the vagaries of the Freudians arise from this fact. However, much light is inevitably thrown upon the subject's behavior by the use of the method. Therapeutically its great value lies in the fact that when the origin and character of a person's fears and worries are explained to him the symptoms gradually abate and may finally disappear; indeed, the cures effected by the use of this method of analysis are largely a matter of the re-education, or re-conditioning, of the subject in forms of behavior which are socially acceptable.

Hypnotism.—Hypnotism, as used by Liébault, Wetterstrand, Charcot, and others in the last quarter of the nineteenth century was the forerunner of the psychoanalytic method. Hypnotism is a method of producing artificial cases of multiple personality through suggestion. The essential procedure is to control the individual's behavior by a monotonous and unchanging stimulus to such an extent that the individual's inhibitions are gradually and partially broken down. As a result the person in the state of hypnosis reacts in an unusual way to the verbal stimuli presented by the experimenter. He may behave as if certain absent visual objects were present and ignore others which are affecting his receptors. Actions may be performed that ordinarily would be inhibited either by the stimuli that are present or by the results of the subject's past training. Things may be said that are utterly unlike his usual speech. After the hypnosis has been removed a total amnesia may exist for the period of its extent similar to the condition which we saw in multiple personality and hysteria. It has been found that commands given the subject during the hypnosis with instruction to

carry them out after normal waking behavior has been reinstated (post-hypnotic suggestion) will be duly obeyed at the appointed time. In this manner the experimenter may suggest that the subject will no longer suffer from certain pains, or morbid fears, or evil habits, and frequently results of much value have been obtained. At times apprehension has existed lest hypnotism be used to further criminal designs. Unless, however, the person hypnotized is already suffering in his conduct from poor control and initiative, there is little danger that the strong inhibition arising from his past training will fail to counteract the suggestions offered.

Self-hypnotism, autosuggestion, also occurs. Here the individual gives himself the command or suggestion, sometimes without being able to say that he has done so. This phenomenon may be illustrated as follows: Normally, when the usual bedtime comes, drowsiness sets in through the action of conditioned reflex mechanisms, whether the individual is fatigued or not. In cases of insomnia, sleep can often be secured by concentrating one's behavior upon some monotonous series of stimuli such as sounds, and those stimuli arising from counting inaudibly. One also may give himself the suggestion to wake at a given hour, and then accomplish the act at the given time. Again, the case of a lady of my acquaintance may be cited who, upon having trouble with her eyes, consulted a local oculist in whom she had little confidence. Glasses were fitted, but the patient shortly thereafter began to have severe headaches. Suspecting that the fault lay in the glasses (with which she had never felt quite satisfied), she consulted a prominent oculist of a nearby city. This physician, after an examination, assured her that the glasses were correct, and the headaches disappeared thereafter!

Conclusion.—The chief personality defect which stands out as a result of the studies of abnormal behavior is *dissociation.* Typically this involves an inability to bring the behavior which is relevant to bear upon the problem at hand. As a consequence arise: the delusions and hallucinations; that uncritical reaction to stimuli which constitutes suggestion; repressed complexes; and all the

other phenomena of behavior which constitute faulty environmental adjustments. In concluding the discussion of abnormal behavior we should repeat the statement that was made at the beginning of the book: no one field can be studied apart from the subject matter of other fields. The picture that we have drawn of the abnormal individual is intimately linked with the picture that we shall have at the close of the book. Human nature is so complex that in order to understand and appreciate it the student must approach it from many sides. In the following chapter on "Social and Racial Anthroponomy" we shall make a further intensive study of human nature, this time with particular reference to the influence of race and society upon the individual.

REFERENCES

Adler, Alfred. *The Neurotic Constitution.* Trans. by Glück and Lind (New York, 1917).

Bridges, J. W. *An Outline of Abnormal Psychology* (Columbus, Ohio, 1925).

Burnham, W. H. *The Normal Mind* (New York, 1924).

Burt, Cyril. *The Young Delinquent* (New York, 1925).

Ellis, H. *The World of Dreams* (Boston, 1911).

Freud, Sigmund. *Interpretation of Dreams.* Trans. by Brill (New York, 1913).

———. *Psychopathology of Everyday Life.* Trans. by Brill (New York, 1914).

———. *A General Introduction to Psychoanalysis.* Trans. by Hall (New York, 1920).

Haines, T. H. "The Genesis of a Paranoic State," *Jour. Abnormal Psych.*, XI (1917), 368–95.

Healy, W. T. *The Individual Delinquent* (Boston, 1920).

Janet, P. *The Major Symptoms of Hysteria* (New York, 1907).

———. *Psychological Healing.* 2 vols. (London, 1926).

Jelliffe, S. E., and White, W. A. *Diseases of the Nervous System* (Philadelphia, 1915).

Jones, E. *Psychoanalysis* (New York, 1913).

Lodge, Sir Oliver, and Others. *The Case For and Against Psychical Belief* (Worcester, Massachusetts, 1926).

Moll, A. *Hypnotism* (4th ed., London, 1897).
Morgan, J. J. B. *The Psychology of the Unadjusted School Child* (New York, 1925).
———. *The Psychology of Abnormal People* (New York, 1928).
Myerson, A. *The Psychology of Mental Disorders* (New York, 1927).
Pressey, S. L., and L. C. *Mental Abnormality and Deficiency* (New York, 1926).
Prince, M. *The Dissociation of a Personality* (2d ed., New York, 1908).
———. *The Unconscious* (New York, 1916).
Taylor, W. S. *Readings in Abnormal Psychology and Mental Hygiene* (New York, 1926).
Wells, F. L. *Mental Adjustments* (New York, 1922).
White, W. A. *Outlines of Psychiatry* (5th ed., New York, 1915).
———. *Mechanisms of Character Formation* (New York, 1916).

CHAPTER IV

SOCIAL AND RACIAL ANTHROPONOMY

I. SOCIAL ANTHROPONOMY

Introduction.—Men and most infrahuman animals show marked differences in behavior when in the presence of other organisms, notably members of the same species. The interstimulation and response which appears under these conditions is the basic fact of social behavior and constitutes the subject matter of social anthroponomy. A strange ant entering an ant neighborhood calls forth characteristic behavior from the ants who live there. A monkey, confined in a cage alone, becomes a different animal upon the introduction of a companion. And so when two human subjects are together new forms of behavior appear which are not evident when the subjects are alone. This behavior is illustrated by such responses as shyness, coyness, and fighting. These are all forms of social behavior. Each is a case where the behavior of one subject serves as a stimulus for the behavior of the other, which then becomes a stimulus for further behavior in the first subject. Social anthroponomy seeks to describe and explain all such cases. It studies customs, traditions, fads, fashions, conventions, the crowd, the public, and the mob. Furthermore, it analyzes law, religion, morals, language, and art in order to indicate and appraise the behavior groundwork of these institutions.

The prime prerequisite for carrying forward these investigations is an understanding of the nature of the individual who enters into the social relationships. This understanding comes from a study of the data of general anthroponomy. Social behavior involves all aspects of the human organism: instincts, repressed complexes, suggestibility, learning, thought, general intelligence, etc. The detailed content of social anthroponomy includes all data which will help explain the social behavior of the individual. Out of this

study of the individual as one of a group grows a conception of human nature which emphasizes the significance of man's life in a social habitat.

The Origin of Society.—It was held by Hobbes and Rousseau that society is an artifact arising from a mutual contract between individuals when this finally became necessary for protection against mutual depredations. Such a view presupposes that there was a time when society or social relations did not exist, and that social relations are to be limited to the fact of organized society and its phenomena. The present point of view differs from that in recognizing the widespread nature of social behavior and in viewing social organization as a natural, unpremeditated result of man's responses to others in the group.

Society is as old as man himself. (We are now ignoring the animals below man.) It is implicit in mating, and is prominent when the family—or a permanent union of the sexes with the consequent care of children—arises. Whether primitive or advanced, social phenomena revolve about the fundamental responses of food-getting and sex. It is necessary to point out that the term sex must be interpreted in the broadest way, covering courtship, mating, family life, and the rearing and education of offspring. Even the most casual inspection will show to what an enormous extent social phenomena are concerned with these activities. The place of food-getting behavior is equally prominent. In primitive times individuals and tribes migrated from localities where food was scarce and sought more fruitful areas. Permanent villages grew up in these places and in locations possessed of trade advantages. Farming, dairying, horticulture, and animal-breeding—all are occupations arising for the production of food. Distribution, requiring the necessary means of transportation, and the final consumption tell the story of all but a very minor portion of social activities. Underlying all of these phenomena is the nature of "the individual as a group member" with his instincts, emotions, peculiarities of thinking, and his other acquired tendencies to action built up partly through inherent processes and partly by the modifying influences of individual training.

The groups possessing the greatest social solidarity, i.e., the most thoroughly co-ordinated interstimulation and response behavior, are groups composed of members of the same species: dogs, cats, wolves, and men. This grouping by species is partly due to the fact that the young belong to the same species as the parents; dogs are born of dogs, and men of men; but it is quite as much due to the conditioning which the young receive in the nest or in the home. The young here learn to approach and stay near other animals, usually of the same species, as a prelude to securing food and warmth. There is no sufficient reason for believing that heredity determines the specific behavior of association with members of one's own species. Kittens reared by dogs become incorporated into the dog group until changing environmental conditions make this no longer possible. Gregarious behavior of the type described, which is sometimes called "recognition of kind," is to be explained along the lines just indicated.

The Place of Instincts in Social Life.—Any thorough account of the individual as social must include a study of instincts because these are the fundamental forms of all behavior. By virtue of his membership in the species, each individual possesses certain characteristic inherited modes of acting called instincts. Here belong such responses as fear, anger, joy, sorrow, grief, jealousy, food-getting, sex responses, etc. Once again, as in the chapter on "Phylogenetic Anthroponomy," we must postpone the detailed consideration of instinct to Part II, and continue to think of it in the fairly general sense of any inherited form of response controlled by the nervous system. The instincts are termed fundamental because all of the later developments in conduct (character) are composed of modifications of this original stuff of human nature. In a very true sense the entire field of anthroponomy centers upon this question of adjustment to environment, whether the adjustment be inherited or acquired.

Instincts may be thought of as social in the sense that as the process of change and growth goes on in each one, social factors are always effective. I learn to fear what my neighbor fears. I secure

my food and mate in the ways prescribed by social usage. My curiosity and jealousy are aroused and terminated in the conventional manner prescribed by the group in which I live. Wherever I turn I am met by social guidance and compulsion. In this respect—and it is an important one—all instincts are social. One may, however, consider the instincts not so much from the standpoint of their conformity to social standards (or vice versa) as from the point of view of the types of situations which arouse them or of the primary functions which they serve. From such an angle the behavior of sex, jealousy, the parental responses, fear, and anger are social in a way that feeding, curiosity, and joy seldom are. The former instincts are aroused in situations where other persons are usually integral parts. Even in the case of anger, where the social element is less uniform, there exists an inevitable tendency to personify the offending object. The elusive collar-button and the threatening cloud alike tend to be treated as if they were persons at the moment of the arousal of the instinct. This is also equally true of fear. The latter instincts of our foregoing list are not so essentially social.

So far, where we have commented upon the modification of instinct, it has always been a change of the type presented in the conditioned reflex which has received attention. We have only stressed the fact that modifications may occur either in the stimulus or the response aspects of the behavior as a result of the individual's past history. Thus after fear responses have occurred in the subject it is possible, by training, to change either, or both, the nature of the stimulus and the character of the behavior. It is important that we now point out the possibility and significance of other kinds of modification. (1) The purpose, or goal, to be attained by the behavior may be changed from that set by heredity. Biologically, fear responses tend to remove the subject from danger; anger works toward the elimination of the dangerous object; feeding serves to nourish the organism; sex behavior leads to reproduction; parental behavior safeguards the young; etc. Socially these various forms of activity in man may be aroused as means to quite different ends. Fear and anger behavior, e.g., are aroused in

large groups of people by their leaders for the purpose of increasing group unity, or solidarity, for those who manifest emotional behavior together and who thus interstimulate each other become to that extent members of a kind, comrades. Sex and feeding behavior are used with smaller groups to secure the same end. The sharing of good things to eat, the breaking of bread together, has been recognized from time immemorial as a method of building up friendship. The strict practice of monogamy involves a similar use of the sex instinct in the interests of family solidarity. In addition to this socially recognized goal for inherited activities, mention must be made of the other purposes of emotional activity and catharsis. Thus the civilized adult eats in order to arouse emotional behavior as much as for nourishment. Art in all its forms presents additional stimuli for the instincts and emotions, serving partly as an emotion-giver and partly as a safety-valve for the individual. One source of the value which attaches to this latter socially established function is the complex restraining modern environment in which man lives, an environment where the premium is upon intelligent rather than upon instinctive adjustment. These changed surroundings and an established social code offer but little opportunity for the exercise of primitive forms of behavior. It is at this point that the arousal of instincts in an approved (or tolerated) artistic form can accomplish a purpose of catharsis and so enhance the hygienic behavior conditions both of the group and of the individual. In the attainment of the social purposes which we have indicated, the biological goal may be approved, satisfied incidentally, or directly combated. (2) The second addition to our account of the modification of instinct is this: Habits acquired prior to the first manifestation of the instinct may modify the inherited behavior when it does appear. The type of modification emphasized by the conditioned reflex involves first the instinct and then its change as a result of training. Our present point is that in the case of those instincts which appear late in the individual's life, particularly sex and parental behavior, one first has certain habits formed which, when the instinct appears, modify it from the start. In this manner

the individual may profit by the experience of others rather than learn at his own expense. This principle affords much of the psychological basis for a program of sex education.

C. O. Whitman was the first to present observations bearing upon the second point which we have presented. Whitman conducted extensive experiments upon the breeding of pigeons, in the course of which he made the following observation:

> If a bird of one species is hatched and reared by a wholly different species, it is very apt when fully grown to prefer to mate with the species under which it has been reared. For example, a male passenger-pigeon that was reared by ring-doves and had remained with that species was ever ready, when fully grown, to mate with any ring-dove, but could never be induced to mate with one of his own species. I kept him away from ring-doves a whole season, in order to see what could be accomplished in the way of getting him mated finally with his own species, but he would never make any advances to the females, and whenever a ring-dove was seen or heard in the yard he was at once attentive.[1]

Whenever the behavior of an animal at any one moment is influenced by the previous behavior which that animal has manifested, the influence is either one of transfer or of interference, facilitation or inhibition. This aspect of the problem we shall discuss later in connection with learning. At present we are interested to emphasize that it is possible to modify the fundamental behavior of sex upon the basis of habits which have been established prior to the appearance of sex behavior.

The chief importance of instinct for society lies in two directions: (1) The instincts furnish the fundamental driving-springs to action in the individual. They also represent solutions for typical recurrent difficulties as these have been worked out in the past history of the species. Customs, traditions, conventions, fads—all must take this fact into account. These habits are built upon the basis of instinct and represent habitual modifications favored by the group of individuals. Thus marriage in its various forms is built

[1] C. O. Whitman, *Orthogenetic Evolution in Pigeons*. Vol. 3. *The Behavior of Pigeons*. Edited by H. A. Carr (Washington, 1919), p. 28.

upon the basis of the sex and parental instincts. Customs of food production and distribution involve the instincts of food-getting, rivalry, acquisitiveness, etc. These modifications and elaborations of instinctive responses are transmitted from generation to generation by education, i.e., by social as opposed to physical heredity. (2) Not only do instincts represent the fundamental responses made by an individual to certain situations that constantly recur within his lifetime, but they are types of behavior which cannot be eliminated. One may repress or modify an instinct so that it seldom recurs or so that it appears in a highly modified form, but one cannot eradicate the instinct totally. Social customs and usages, when they are successful, recognize this fact. The sex instinct cannot be eliminated or successfully repressed. The Middle Ages saw the failure of such a doctrine, and Freudianism at the present time is contributing further data. Hostility, jealousy, rivalry, and the other instincts are likewise permanent features of the organism's behavior system. Social groups can modify but cannot destroy these forms of response. Hostility may be sublimited from sheer animal attack, as in war, to the more subtle conflicts of wit and cleverness; yet ever and anon the repressed animal form of combat makes its appearance and dominates behavior.

Human and Infrahuman Fighting.—An excellent contrast between human and infrahuman social behavior is presented in the interstimulation and response of fighting as it occurs in the two groups. There are many reasons why men fight, but perhaps we shall not be far wrong if we list the following as the most important reasons: (*a*) emotional and instinctive excitement, as in anger and fear, (*b*) defense mechanisms against a loss of self-respect, (*c*) the relative ease with which instinctive or traditional modes of response may be used in place of the more difficult and action-inhibiting behavior of thinking, (*d*) faulty stimuli which result from misinformation or misrepresentation, and (*e*) a serious interference with one's modes of behavior. With the infrahuman animals, only factors *a* and *e* seem to be effective. These animals fight, as Craig points out, primarily because their territory has been invaded or

their interests (forms of behavior) interfered with. Fighting behavior does not have an appetite component as do sex and feeding responses. Infrahuman animals never go around "looking for a fight" as they go in search of food. Only man shows this perverted form of behavior.

Human fighting differs from the fighting of other organisms through the presence of the following characteristics: deferred aggression, murder, the use of tools, organization, and, in some cases, an "appetite" for fighting. Animal fighting rarely results in the death of one of the combatants where these are of the same species. Rather, when one animal is defeated it leaves the field. And once out of range, neither the victor nor the defeated behaves with reference to the absent opponent! There is no vengeance or deferred aggression. Infrahuman animals do not organize for war. They hunt other species than their own in packs, sometimes, but this is food-getting behavior, not war on their own kind. Infrahuman animals are notably peaceful with other members of the same species; and when fighting between members of the same species does break out, it is rare that death or serious injury results.

Why does fighting within the human species differ so markedly from that within the other animal groups? There is one fundamental and all-important reason: Man has ideas, symbolic processes, and the other animals lack them in any highly developed form, if not entirely. By means of symbolic processes (which we have discussed in connection with the delayed reaction and which we shall again discuss in the final chapter) man can behave with reference to absent objects. When his enemy has escaped, man can have his own behavior controlled by substitute stimuli as a result of which he can go and search for the enemy, or erect defenses against his return, or *think* "A dead enemy is forever out of the way." The use of these substitute stimuli, symbolic processes, makes the construction of tools possible. Before the invention of tools, by which we mean the use of inorganic materials under the control of language processes, men could have killed each other only with the greatest difficulty, had they tried; but given both ideas, i.e., lan-

guage processes and tools, the fundamental behavior equipment for homicide is present. Not only are ideas necessary for the planning and use of tools, but their presence in an animal makes possible such organizations as armies. Organization itself is present in the pack, but symbolic processes are absent.

Social Uniformities.—The importance for social behavior of those fundamental aspects of human nature included under the terms "instinct" and "emotion" has not been exhausted by our preceding account. Indeed, there we have been chiefly concerned with one point, viz., the possibility of development in the individual's hereditary equipment. One of the large problems in the field of social behavior is that of the uniformities in behavior manifested by members of a group. Why do people act alike in so many cases, as they do, e.g., in following fashions, in conforming to custom, and in participating in mob action? A partial cause of these uniformities lies in the common hereditary equipment of individuals. Much, however, is determined by the modifications of this behavior which arise from life in a common environment. Concerning the mechanisms involved in these modifications we have already had something to say. Great emphasis has been laid by other writers upon two specific forms of behavior as factors in the development of uniformity. These are imitation and suggestion. It is to the development of this topic that we now turn. The rôle of instinct we may pass over with the reminder that gregariousness occurs primarily between those animals whose fundamental behavior has been conditioned in the same home during infancy, and that the minor groupings which later occur are between individuals who have together been stimulated to such behavior as feeding, fear, anger, and love.

Imitation.—Gabriel Tarde and J. Mark Baldwin in particular have stressed the rôle of imitation in shaping social uniformities. In general, to imitate is to duplicate the actions of another; but action No. 2 is not an imitation of action No. 1 merely because the two are similar. Two persons may sneeze simultaneously or wear straw hats at the same time, and yet the relationship between the

two forms of behavior is not one of imitation. The sneezing may be due to the fact that each individual has his nasal passages irritated at the same time. If, on the other hand, the sneeze by Subject No. 1 is the stimulus (visual or auditory) which arouses the sneeze in subject No. 2, the case is one of imitation, and the mechanism involved in subject No. 2 is that of the conditioned reflex. Subject No. 2 might have responded to No. 1's sneeze with a laugh, and in this case we should not have said that he imitated No. 1's behavior. In order to be a case of imitation the behavior of subject No. 2 must not only be aroused by the behavior of subject No. 1, but No. 2's behavior must be equivalent to that of No. 1. In a later chapter on "The Correlation of Stimulus and Response" we shall discuss the nature of equivalent responses. In the present connection we can make our point clear by pointing out that, when a dog chases a rabbit, the dog is not imitating the rabbit, although both are running and although the dog's running is caused by the running of the rabbit. Both animals are engaged in locomotion, but the result to be achieved by the dog is *food-getting,* while the result to be achieved by the rabbit is *escape.* The two responses are not equivalent, and therefore they do not constitute a case of imitation.

Although imitation, as just defined, does occur, there is no evidence that it is ever instinctive. To be instinctive imitation the two responses concerned must not only be equivalent, but behavior No. 1 must arouse behavior No. 2 as a result of heredity and not of learning. Animal No. 2, e.g., must respond with a sneeze when stimulated by a sneeze in animal No. 1 because the behavior of animal No. 1 is an unlearned stimulus for No. 2's sneeze. Such a statement assumes that by heredity one or more instincts may be aroused, not only by dangerous objects (fear) or by annoying objects (anger), but by the instinct itself as it occurs in another. Thus, to speak of an "instinct of imitation" is to say that by heredity the stimulation from fear in another arouses fear in the beholder, the stimulation from anger arouses anger, etc. But the stimulation from fear in another may arouse joy, shame, anger, or almost any other action in the beholder. The fact that fear is often con-

tagious does not indicate that fear is itself the stimulus which brings about its spread throughout the group. The keenest criticism of such a point of view we owe to Thorndike (1913). He writes:

> The spectators of an infuriated man, or of two men raging at each other, are not thereby provoked to similar acts and feelings. They manifest rather "curiosity-wonder," forming a ring to stare, the world over. So with other mammals. When Professor McDougall wrote that "anger provokes anger" he probably had in mind the fact that angry behavior of A toward B provokes angry behavior of B toward A. But that is irrelevant to his purpose, since he surely does not wish to contend that A's fleeing from B makes B flee from A, that A's shrinking from B makes B shrink from A, that A's self-abasement before B makes B abase himself before A.[2]

The whole difficulty lies in making sure in any particular case of imitation whether the similar responses are not due to the fact (1) that each animal concerned receives the stimulus that affected the first or imitated animal, or (2) that the imitated behavior itself contains a signal or stimulus for its repetition by others. So Thorndike continues:

> Under present conditions children would usually learn by training to run from what others ran from, to look at whatever others looked at, and the like, even if there were no original tendencies to do so. Moreover the object or event, the perception of which causes A to respond by a certain instinctive behavior which then spreads to B, is likely to be perceived by B also, so that whether his behavior is a response to A's behavior or to the object itself is often in doubt. For example, A's fear at a snake may arouse B's fear indirectly by merely calling B's attention to the snake. Finally A's response may, upon his perception of B, be modified to include certain behavior which acts as a special signal to provoke approach, fear, or whatever the response may be, in B. Thus the danger-signal might be given by A when frightened in company, though not when frightened alone; and B might respond, not to A's general fright, but to the danger signal.[3]

[2] E. L. Thorndike, *The Original Nature of Man* (New York, 1913), p. 119.

[3] *Ibid.*, p. 120.

Since there are probably no cases of instinctive imitation, we may say that all cases of imitation are to be explained either in terms of conditioned reflexes or in terms of thinking. Let us take the former case first. Suppose I yawn in response to your yawn; How is the imitation to be explained? The unconditioned stimulus for a yawn is a condition, *x*, arising from drowsiness and the accumulation of waste products in the body. Inasmuch as you and I live in the same general social environment, sleeping at about the same time, the condition *x* will often appear in each of us at about the same time. We will therefore often yawn at the same time. When you yawn, I am stimulated visually and auditorily at the same time that I am stimulated by condition *x* within my own body. The visual and auditory stimuli thus become conditioned to my yawn, so that they can set off the response even in the absence of *x*. I therefore often yawn when you do, and because you do, although I am not drowsy.

Undoubtedly man often behaves as others behave, and as a result of their behavior, after having first indulged in thinking. If I see you secure $1,000 by labor, my first response may be the verbal behavior "I can go and do likewise," and my second response may be to go and do likewise. There is no sufficient evidence that such imitative behavior controlled by symbolic processes occurs in the animals below man. How often it occurs in man it is impossible to say. The introduction of symbolic processes into behavior enormously complicates it by the introduction of the possibility of response in the absence of the original stimulus. However, the mechanism involved is still one of habit-formation and of the influence of one form of behavior upon another.

There is no minimizing the importance of imitation in the preservation of the group through its effect upon team work and uniformity of action. Cattle that did not stampede after their leaders would in time fail to survive. Social groups whose members did not act as other members act would disintegrate. Perhaps the strongest reason for imitative activities in general lies in the helplessness, restlessness, and fear that come with the isolation from (non-con-

formity with) the group. Later, in the discussion of custom, we shall meet certain of the methods adopted by the group to compel conformity to, or imitation of, its ways. Here we can only state that imitation does not seem to be a distinct capacity making for adaptation, as is the case with such factors as instinct, learning, and thinking. *Imitation is rather a term referring to behavior uniformities which have as a partial stimulus the equivalent behavior of other individuals.*

Suggestion.—Suggestion is the second factor upon which particular stress has been laid in explaining the social behavior of the individual. It is difficult and unnecessary to keep it separate and distinct from the imitative process. Ordinarily suggestion is defined as the process of responding uncritically to a stimulus encountered in social situations. Suggestion would therefore be set off from other forms of behavior upon the basis of the amount of relevant previous training which enters into the determination of a response.

We have already encountered the phenomena of suggestion in our study of abnormal behavior. Suggestibility is favored by any factors that tend to put the critical powers of the individual off guard and that permit a response to obtrude itself with little or no critical consideration. Resistance to suggestion goes along with a wide and highly organized past training. As a result, women, children, and members of the more primitive races are in general more open to suggestion, to the uncritical manifestation of behavior, than are men, adults, and the more cultivated races. We may follow Ross, in the main, in listing the factors that aid suggestion: prestige, age, race, sex, emotional excitement, repeated stimulation, and being but one person out of many. By prestige we refer to the effect of authority in securing the unresisting acceptance of a mode of conduct. Let a high critic of art pronounce a picture poor, and immediately for many the picture is no longer artistic. Let custom through some of its representatives say that such and such conduct is wrong, and the edict is unquestioningly accepted by most people. I write an account of suggestion, and the students more or less uncritically accept it as true because as a writer of books I have pres-

tige and authority! This factor is a valuable and unavoidable aid in the dissemination of uniformities in response among a group of people, the chief safeguard, however, being that the prestige emanate from ability. In many cases prestige depends upon the age, race, or sex of the leader; thus we may group these factors as subordinate ones under the main one of authority. Insistent, insidious repetition will also break down and overcome resistance and cause forms of behavior to appear which would not otherwise have happened. Familiarity breeds acquiescence. The effects of the other two factors, emotion and numbers, we may best illustrate under the topic of mob action, to be discussed below.

Social Institutions.—By a social institution we shall mean any of the more stable and permanent relationships entered into by individuals. Society itself is a social institution. We mentioned others at the beginning of our present chapter: fashions, conventions, traditions, the mob, the crowd, the public, religion, morals, law, language, art, etc. It should be clear that only a part of the individual is involved in each institution. One part of the individual's organization of behavior will be found particularly emphasized in fashions, another in morals, another in religion. It would far exceed the scope of our present bird's-eye view of the field of social behavior to discuss many of these topics in detail, for each in turn calls not only for an analysis of the institution, but also for a survey of the changes and the factors causing constant changes in this institution. Accordingly we shall limit our present account to brief comments upon the nature of custom and the mob.

The Nature of Custom.—Customs are uniform modes of acting which are transmitted by social heredity from generation to generation. Thus one finds religious, moral, commercial, legislative, and other customs. They differ from ordinary habits in that their age extends back of the present generation and in that they are habitual responses common to a large number of individuals. Like habits (see the discussion below, p. 275) they arise partly by chance and partly as a result of thinking. Perhaps in each case both factors are active, varying only in relative amount. Particularly in primi-

tive customs does chance play a dominant rôle. Let us describe a hypothetical but typical case of custom-formation in hunting, remembering that the securing of food is a matter of tremendous importance in primitive life, that strong emotions are involved, and that as a matter of life and death the savage can afford to ignore no power that may aid him. On the morning of the hunt he comes from his shelter and stumbles. The day proves unfruitful. Stumbling becomes an omen of bad luck, a thing to be eliminated from the procedure of hunting. In like manner the full moon may also become associated with poor hunting, and the custom be confined largely to the dark of the moon. If failure attends the hunting for several days and then gives place to success shortly after the hunter has rubbed the bow three times and said to himself, "O arrow, shoot straight," this practice becomes incorporated into the hunting procedure, is taught to the hunter's friends and children, and finally becomes a well-established custom. Present-day society is replete with such modes of acting that had origins similar to the foregoing, but that now persist in an alien environment as responses that might well be termed vestigial. "Do not plant potatoes in the dark of the moon." "Do not pass a pin without picking it up." "Thirteen is unlucky." These useless and more or less rejected customs rest upon a defective analysis of the relation of cause and effect in nature. The reason why the foregoing injunction about potatoes does not influence most of us is that we can detect no causal relationship between growing potatoes and the phases of the moon. In a like manner the superstitions concerning the number 13, the spilling of salt, and many other acts do not generally affect us. Among the more intelligent classes the tendency is to form all essential customs upon the result of reflection. For this reason laws are drawn up by deliberative assemblies. Rules of planting and reaping are devised at the agricultural colleges. Yet even with the most intelligent, a fairly large field of behavior remains under the reign of chance, partly because—as with the number 13—the situations are not vital for the individual, and partly because some customs, such as religion, the control of sex behavior, and the right of property,

involve such tremendous issues that society fears to tamper with accepted custom lest great evil result.

What are the factors that give custom its grip on the individual? They may be listed as follows: (1) fear aroused by the unknown and the unusual that are to be found just outside of the customary mode of action; (2) the ease, convenience, and lack of fatigue in doing the accepted; (3) the prestige of the old; (4) the effect of public opinion. The more important the custom to the individuals concerned, the greater is the influence of the first factor. The primitive man will not depart from his hunting custom or from his method of caring for his cattle, because to do so is to leave a successful form of response for untried possibilities with suffering and death the penalty of failure. Present-day peoples are loath to depart from the customary marriage regulations for much the same reason. It is to run the risk in this very important social problem of "jumping from the frying-pan into the fire." And then, too, in all of these cases it is much easier to act than to think. The path of the reformer is always hard and seldom attractive. The prestige of the old, the third factor mentioned above, is the prestige of that which has worked well enough at least for survival. As a group, China with its ancestor-worship and India with its caste system are perhaps the most striking illustrations of this factor. Public opinion has its effect upon the individual partly through the great prestige and suggestive power that attach to large numbers, and partly through the reaction against the ostracism and isolation that result from non-customary behavior.

The Mob.—Customs are relatively permanent social institutions, i.e., uniformities in social behavior. Mobs are relatively transient. Many individuals may never take part in social relations that even remotely approximate mobs, but no individual avoids custom. In a mob we have essentially an aggregation of individuals whose behavior is dominated by a certain exciting situation. Even an isolated individual will behave in inefficient and unsanctioned ways when excited. The individuals who make up the mob are not only excited, but a variety of other factors operate to release them

from the customary inhibition which blocks asocial behavior. Such factors as the following may be mentioned as the most important: (1) the practical impossibility of punishing so large a group; (2) the high degree of probability that the police will not shoot to kill; (3) the mere participation of large numbers of individuals in the mob's activities indicates the approval of the mob's activities by a considerable social group; (4) in many cases it is known that local political pressure will block the administration of justice to the members of the mob; and (5) the difficulty of identifying members of the mob or of assessing their individual responsibility.

We will be helped in our understanding of the mob if we attempt to list the specific factors, in addition to the foregoing, which make for mob action. First, there is the real cause for the excitement, a murder, for example. This actual event usually becomes seriously misrepresented through gossip, and it often is presented to the public in an exciting manner by the press. Such misinformation serves to arouse undue excitement and uncertainty. This excitement and random activity we may list as the second factor. Third, through the excitement the individual becomes more than usually suggestible. Fourth, individuals congregate at the places connected with the crime. Fifth, this congregation of individuals brings with it the moral sanction of numbers and an irresponsibility, as indicated in the preceding paragraph. Sixth, the congregation of individuals usually contains hoodlums and members of the criminal classes who are there of their own initiative or who are placed there by parties interested in arousing the congregation of people to action. And seventh, many of the individuals in the mob possess repressed complexes which are specifically released under mob conditions.

Can mobs be prevented? Real causes, i.e., murders, rape, racial conflicts, and other similar events, cannot be prevented. Public opinion, however, can be educated against a tolerance of mob action, and unbiased information calculated to allay excitement can be given out by the radio and the press at the time of threatened trouble. *If* individuals are allowed to congregate, excited by unfor-

tunate information, then the active presence of factors two to six is inevitable, and the violent, suggestible, childish activity of the mob is almost certainly assured.

Other institutions of society we must leave undiscussed and proceed to an even briefer sketch of racial anthroponomy.

II. RACIAL ANTHROPONOMY

Introduction.—On page 27 we listed three varieties and ten subvarieties of living man. Using the term "race" as synonymous either with the term "variety" or with the term "subvariety," racial anthroponomy concerns itself with racial differences and likenesses in behavior. Primary emphasis is placed upon the study of the four fundamental topics which we have earlier (p. 15) indicated to be the chief subject matter for the science: learning, language responses, interstimulation and response, and behavior tests. To what extent do the customs of races differ, and what are the contributing causes? What are the relative abilities of different races when examined by the method of behavior tests, or by a comparison of those learned forms of response which constitute their respective institutions? To what extent do races differ in the capacities displayed in language? The question in all of these problems is, "How will individuals vary in behavior in virtue of their membership in different racial stocks?" There is no doubt but that social behavior is modified definitely by racial membership. Individuals possess standards of conduct, prejudices, prepossessions, and ideals derived from historical conceptions of race which modify their behavior toward others. Thus much is assured. It is, however, quite undetermined to what an extent racial membership determines behavior through inherited nervous mechanisms.

The questions just raised indicate clearly that the topic of racial behavior is related very intimately to anthropology and ethnology. Most of its facts and theories are, up to the present time, the fruits of investigators who are not primarily anthroponomists. The situation is in process of fairly rapid change now to the extent

that behavior tests are being applied, and in the future one may expect accumulations of facts bearing upon relative intelligence that have been subjected to the most rigid scientific standards. The most extensive data of a reliable nature at the present time consist: (1) of descriptions of the customs of different races with some suggestion of their geographical, economic, and social causes; and (2) of physical (anthropometric) measurements, showing particularly differences in skull capacity and form. The great and fascinating field of primitive custom and culture we shall pass over in this chapter, though in the preceding account of social behavior we have described a few of the factors underlying their formation and preservation. The topic here to be presented for the purpose of illustrating the concrete problems of racial anthroponomy is that of racial differences in general ability.

Racial Differences in General Ability.—The general question of inferior races is not whether or not there are inequalities in racial attainments, for there is ample evidence that all are not favored sons. The essential problem is whether or not there are inherent differences in ability. The question we are raising is scientific and not ethical. Cannibalism, polygamy, and ancestor-worship may be thought to be inferior in moral worth to the corresponding practices of Europeans; yet it does not follow that the adherents of these customs are inferior in their behavior capacities. They may be able to respond to as many stimuli for the various senses as we, and their powers of thinking may be of a high grade. On the other hand peoples, races, may share the same customs and culture and yet differ more or less in adaptive ability. There has been a very strong tendency to treat all racial stocks as inferior to the European partly because the present European has assimilated and outdistanced more primitive races and partly because today the "lower races," i.e., the Africans, Australians, American Indians, and others, vanish and fade before his advance. Boas (1901, 1911) and other anthropologists do well, therefore, when they point out social, economic, and physiological reasons for race predominance. Mod-

ern occidental contact with more primitive races no longer is one of assimilation and intermingling, but largely one of exploitation. Roman culture conquered its barbarous captors in the final end of the empire, but prior to that the Romans had mingled more or less freely with their colonials. The Mohammedans absorb the native peoples that are below them, while the Caucasians do so almost not at all. At the present diseases of civilization, e.g., venereal diseases and tuberculosis, attack the newly found races more than was apparently the case in earlier racial contacts, and thus aid racial differences in survival. In evaluating the great spread of occidental control over the world, note should also be taken of the fact that relatively high civilizations (e.g., those of the Aztecs and Incas) have existed among races now extinct. Granted that these races were 4,000 years behind in culture, yet when one considers this in comparison with the age of man, Boas points out that accidental causes, and not inferior ability, may well explain the facts.

It has long been urged that many of the primitive races reveal their inferiority in their language. One mark of intelligence is the ability to respond to sameness or identity in widely differing stimulus objects. This is the capacity for acquiring workable symbols, or ideas. Primitive races, it has been said, make too many irrelevant distinctions. They may call a small nut one thing and a large nut another, and yet may have no word for both. They are unable apparently to see that while the nuts are different, yet nevertheless they are both nuts and very similar. Or again words will exist for many kinds of horses according to color, and yet there will be no general word for horse. In other words, so the criticism goes, primitive races have more words than ideas. It is this general point of view that Hocart (1912) criticizes most brilliantly, pointing out that a language must be judged, not in terms of dictionaries, but in terms of its suitability to a particular environment. The reason why one race will make many distinctions with certain objects and relatively few with others is because the former objects have many

specific uses and the latter few. Let us illustrate by a quotation from Hocart:

> The Solomon Islands possess a most useful nut, the kanary, which engrosses much of the islanders' interests and fills much of their existence. In those parts investigated by Dr. Rivers and myself they distinguished two kinds; the *vino* and the *ngari;* in our eyes it was merely a difference in size, and we might never have considered them otherwise than as large and small specimens had not the natives given us the two words. Yet closely related as they are, they have no common term. Had we proceeded no further, we might have ascribed this deficiency to an "incapacity for clearly apprehending identity in difference." But is it reasonable to suppose that an identity so glaring could not peep through the thin veil of differences? . . . . We found that from trifling differences sprang a host of momentous ones—technical, commercial, and religious: the seasons of the two do not coincide; they are gathered differently, because the branches of the *vino* will bear a man and the *ngari* will not; they are cracked differently; . . . . they are preserved differently; . . . . the two, in fact, are only identical in the kitchen, and therefore they have but one word for the roasted kernels and puddings of either.[4]

Again an illustration from the Fijian language will show the opposite side of the matter. Where the group has no particular behavior with reference to certain objects, there it makes no fine distinctions—not because it lacks the ability, but because such distinctions would be useless in its social existence. In English "a cock crows, a hen cackles, a pigeon coos, a jackdaw caws, other birds sing or chirp or warble, but they cannot cry as they all do in Fijian. Is Fijian therefore more advanced in ornithology? On the contrary, it is because they take no interest in birds that they have but one word. . . . ."

So one might continue citing peculiar cases in different languages where distinctions that we might regard as necessary are lacking and unnecessary ones are present. But one really need not go outside the English language. Every special field has its partic-

[4] A. M. Hocart, "The Psychological Interpretation of Language," *British Journal of Psychology,* V (1912), 272, 275.

ular vocabulary. Experts in most fields regard those who cannot use their jargon as more or less inferior beings! The farmer, the horseman, the mechanic, the student of behavior—all find it necessary to draw certain distinctions and to omit others. To most of us horses are all of a kind, and one rock is much like another. But the specialist speaks of mares and stallions, and of chalks and limestones and shale. Some environments make greater demands on their inhabitants than others, and therefore stimulate more varied accomplishments, although the peoples concerned may be of equal ability. There is no question but that all men can learn, think, and respond instinctively. All can be stimulated by light, sound, and contact. There is little reason to believe that savages have more acute senses than civilized man. It is true that they respond to slight sounds and faint trails that escape the townsman; but he too can respond to them if he will practice.

The chief differences between European stocks and the so-called inferior races will undoubtedly be found in general ability as revealed by tests of the kind described in the chapter on "Individual Anthroponomy." Very significant beginnings have already been made with particular reference to a comparison of whites and Negroes in this country. This work, carried on by Mayo, Baldwin, Ferguson, Peterson, and others, including the army psychologists, indicates a significant superiority of the white over the black in general intelligence, i.e., in learning capacity, or ability to adjust to novel situations. Investigations by Rowe, Garth, and Hunter reveal a significant difference between whites and Indians in ability to score in behavior tests of general ability. Evidence has been presented indicating that degree of ability varies with degree of white blood, pure whites ranking highest and pure Indians lowest. The correlation of test score and degree of white blood in one case, using 151 fifteen-year-old whites and comparable numbers of one-fourth, one-half, three-fourths, and full-blood Indians, was –0.51, P.E. 0.017. This general problem of the comparative psychology of races is one of great interest, but one in whose solution scientists have only started.

Résumé of Part I.—Anthroponomy, it will be remembered, is a science of human nature. And the purpose constantly before it is to understand by scientific analysis just what a human individual is with particular reference to his behavior. To gain this understanding one must consider what characteristics in this respect man has by virtue: (1) of his relationship to infrahuman animals; (2) of his relative ranking in ability in his particular population; (3) of the abnormalities that he is prone to share or to develop; and (4) of his membership in a certain society and a certain race. We have now completed a survey of these fields. It remains in Part II, "Normal Human Adult Anthroponomy," to characterize man from the standpoint of those forms of behavior which all men possess in a degree dependent upon the influence of those factors which we have just outlined.

REFERENCES

ALLPORT, F. H. *Social Psychology* (Boston, 1924).

AMES, E. S. *The Psychology of Religious Experience* (Boston, 1910).

ANGELL, NORMAN. *The Public Mind* (New York, 1927).

BARTLETT, F. C. *Psychology and Primitive Culture* (New York, 1923).

BOAS, F. *The Mind of Primitive Man* (New York, 1911).

BRIGHAM, C. C. *A Study of American Intelligence* (Princeton, 1923).

CRAIG, W. "Why Do Animals Fight?" *Internat. Jour. Ethics,* XXXI (1921), 264–78.

DE LAGUNA, G. A. *Speech: Its Function and Development* (New Haven, 1927).

ELLWOOD, C. A. *Introduction to Social Psychology* (New York, 1917).

FERGUSON, JR., G. O. "The Psychology of the Negro," *Archives of Psych.,* Vol. XXV (1916), No. 36.

HOCART, A. M. The "Psychological Interpretation of Language," *British Jour. Psych.,* V (1912), 267–80.

HUNTER, W. S. "The Modification of Instinct from the Standpoint of Social Psychology," *Psych. Rev.,* XXVII (1920), 247–69.

HUNTER, W. S., AND SOMMERMIER, ELOISE. "The Relation of Degree of Indian Blood to Score on the Otis Intelligence Test," *Jour. Comp. Psych.,* II (1922), 257–77.

LEUBA, J. H. *A Psychological Study of Religion* (New York, 1912).

McDOUGALL, WILLIAM. *An Introduction to Social Psychology* (4th ed., Boston, 1911).

MAYO, M. J. "The Mental Capacity of the American Negro," *Archives of Psych.* (1913), No. 34.

ROBINSON, J. H. *The Mind in the Making: The Relation of Intelligence to Social Reform* (New York, 1921).

ROSS, E. A. *Social Psychology* (New York, 1908).

TARDE, G. *The Laws of Imitation.* Trans. by Parsons (New York, 1903).

THORNDIKE, E. L. *The Original Nature of Man* (New York, 1913).

WOODWORTH, R. S. "Racial Differences in Mental Traits," *Science* N.S., XXXI (1910), 171–86.

YOUNG, K. *Source Book for Social Psychology* (New York, 1927).

PART II. NORMAL ADULT ANTHROPONOMY

CHAPTER I

THE NERVOUS SYSTEM

Introduction.—The function of the nervous system is the coordination of receptors and effectors, and consequently the control of behavior. Nervous impulses arise in receptors as a result of stimulation. They are transmitted to the effectors over the neurones which constitute the cellular material of the nervous system. What behavior shall appear depends upon what effectors are activated, and this, in its turn, depends upon the particular pathways which the nervous impulse follows through the maze of neurones. In the present chapter we shall learn that the neurones are connected with each other at synapses. It is at these synapses that current opinion places those variations in resistance which determine that a nervous impulse shall arouse one effector and not another. In some cases the resistance at the synapse is determined by heredity. This is evidenced in those forms of unlearned behavior which occur at birth, such a form of behavior, e.g., as the sudden withdrawal of the foot from a pin-prick in the foot. If there were no predetermined pathway in the nervous system underlying such a response of withdrawal, the whole organism would become active following the stimulus of pin-prick on the foot. Such a stimulus does not result in sneezing or in the contraction of the pupil because the nerve pathways do not conduct the nervous impulse to the effectors required in those activities. In some cases the resistance at the synapse is determined by learning. This is the fundamental reason why a pin-prick on the foot of an adult human subject may result in the verbal response "pain" and cannot have this result in an infant.

As we progress in the present chapter we shall acquire an understanding of the mechanism to which we must turn more than to any other in order to explain behavior. To be sure we have not excluded from other chapters data on neural functions, nor have we

accumulated in the present chapter all of the data which throw light upon the nature of nervous processes. Rather we have made of the present chapter a brief survey of those anatomical aspects of the nervous system which it is most essential to know in order to use intelligently the various accounts of function which are encountered elsewhere in the book.

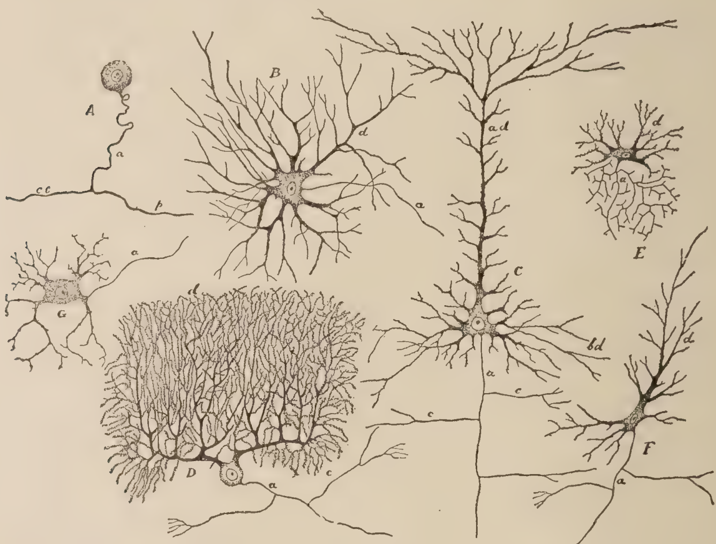


FIG. 24.—Typical neurones (from Morris)

"*A*. From spinal ganglion. *B*. From ventral horn of spinal cord. *C*. Pyramidal cell from cerebral cortex. *D*. Purkinje cell from cerebellar cortex. *E*. Golgi cell of type II from spinal cord. *F*. Fusiform cell from cerebral cortex. *G*. Sympathetic, *a*, axone; *d*, dendrites; *c*, collateral branches; *ad*, apical dendrites; *bd*, basal dendrites; *cc*, central process; *p*, peripheral process."

The Neurone.—We shall begin our study with the neurone, which is the structural unit of the nervous system. It is composed of a *cell-body, dendrites,* and an *axone.* The entire nervous system is built up of cells many of which are these true nerve-cells, but many of which are supporting ones, *neuroglia,* non-nervous in function. Figure 24 shows typical nerve-cells and their attached fila-

ments. A neurone differs from other cells in the body in that its special function is the conduction of energy, the nervous impulse. This function we saw on page 51 to be one of the general characteristics of protoplasm. Beginning students often get the impression that neurones are always microscopic in size, a condition that is frequently true. All are microscopic in diameter, but many of them are several feet in length. One neurone, for example, extends from the top of the brain (pre-Rolandic area) to the lower part of the spinal cord at about the level of the first sacral vertebra (in the small of the back). Again, one neurone may extend from the sacral region of the cord to the tip of the toe. The cell-bodies themselves range in size from 1/160 to 1/6,000 of an inch in diameter; the axones, from 1/2,000 to 1/100,000 of an inch in diameter. As many as 100,000 of these latter may be bound together, like a cable, with connective tissue to form a *nerve*.

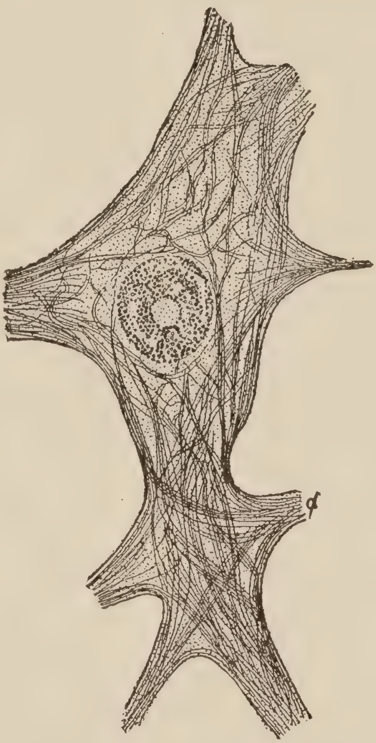


FIG. 25.—The cell-body of a neurone stained to show the neurofibrils (after Bethe).

The cell-body contains at least two substances of great importance: the neurofibrils, shown in Figure 25, and chromatin. The former extend out into the axones and may serve in the conduction of the nerve impulse. The chromatin (so named because of the ease with which it takes up the stains used in microscopic work) is intimately concerned in the metabolism of the neurone.

When an animal has been excessively fatigued, microscopic examination of the cell-bodies shows that the chromatin has broken down and is scattered in small fragments throughout the cell-body. This is called chromatolysis (see Fig. 26). It sometimes even happens that the exhaustion is so complete that the cell-walls themselves

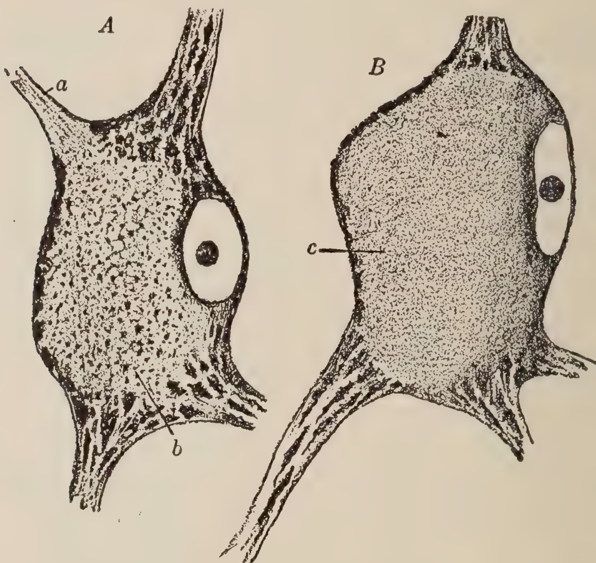


Fig. 26.—Cell-bodies of two motor neurones showing chromatolysis. *B* is the more advanced stage (from Herrick after Cajal).

break down and the neurone degenerates and is absorbed. The probable function of the cell-body is the nutrition of the neurone. It may incidentally slow down the transmission of the nerve impulses. In times past it has been regarded as the seat of "psychic processes," as the most important part of the nervous system, and as the possible originator of many nerve impulses. It is still possible to view some sudden metabolic change in the cell-body as an occasional cause of nerve impulses.

The axone is *efferent* in function, that is, it conducts the nerve

impulse away from the cell-body. Typically there is only one axone to a neurone, and it is smooth in outline, with branches at right angles. The dendrite is *afferent* in function, that is, it conducts the nerve impulse toward the cell-body. The number of dendrites per neurone varies from one to a great number, and they are usually rough in contour with their branches at oblique angles. These facts are shown in Figure 24, p. 152.

All axones of the central nervous system (see p. 159) and the dendrites of the neurons composing the spinal sensory nerves are covered with a *myelin (medullary) sheath,* a fatty substance secreted by the neurone, Figure 27. This sheath serves to insulate and support the inclosed *axis cylinder* and may play some further part in the conduction of the impulse. It is white, and axones covered with it make up the major part of the "white" portion of the spinal cord and brain. The axones of the sympathetic nervous system (see p. 159) lack this covering and are gray in appearance. Those axones and dendrites that belong to the cerebro-spinal system and yet lie outside the central nervous system (the fibers of the peripheral nerves) possess a second sheath, the *neurilemma,* which probably functions in the regeneration of a destroyed fiber, Figure 27. If a motor nerve is cut outside the spinal cord, the fibers degenerate and the person is temporarily paralyzed in certain muscles. The cells making up the neurilemma, however, do

FIG. 27.—Fragments of two nerve fibers. The outer white layer is the neurilemma. The black sheath is the medullary one. The gray central portion is the axis cylinder.

not degenerate. In the course of time a new nerve fiber is developed, and the paralysis disappears. If on the other hand the injury, or *lesion,* occurs in the spinal cord or brain where the neurilemma is absent, the pathway interrupted either never regenerates or else does so very slowly. In these cases the *paralysis* or the *anaesthesia,* loss of sensitivity, may be permanent. Where recovery of function does occur, it is most probably due to certain other structures taking over the function of the destroyed tissue (so-called vicarious functioning).

The Reflex Arc.—The functional unit of the nervous system is the reflex arc. By this statement is meant that the reflex arc is the least segment of nerve tissue that can carry out the function peculiar to this system, viz., the correlation of receptors and effectors. The reflex arc includes at least two neurones and usually many more. It may be further defined as *any nervous pathway between a receptor and an effector.* Figure 28 represents a cross-section of the spinal cord and several simple reflex arcs. If more than two neurones are involved, all but the first and last are termed *association neurones.* The first one is the (afferent) *sensory neurone,* while the last one is the (efferent) *motor neurone.*

The union between two neurones is the synapse. This connection is physiological (functional) and not anatomical (i.e., there is no tissue continuous from one neurone to the other). Figure 28 makes clear the statement that the determination of the pathway over which a nerve impulse shall pass is made at the synapse. In this figure the nervous impulse comes in from the skin to the spinal cord. Here it may go over either one or both of the two pathways. The direction which it does take depends upon the relative amounts of resistance encountered at the two synapses, for the impulse takes the path of least resistance. What the exact nature of this resistance is we are unable to say. It may be due either to chemical or to mechanical changes. Learning is synonymous with the elimination of certain pathways so that more and more of the nerve impulse is carried exclusively to a certain muscle or set of muscles. Intelligence, too, is largely a question of the particular synaptic connec-

tions that function in a given individual. An individual would not be rated as intelligent if a pain impulse resulted in such a contraction of the muscles as to lead to retention of the injurious object, nor is one intelligent whose muscles respond as a laugh when they should bring forth a sob. What response shall be made depends fundamentally upon the synaptic connections available, either as

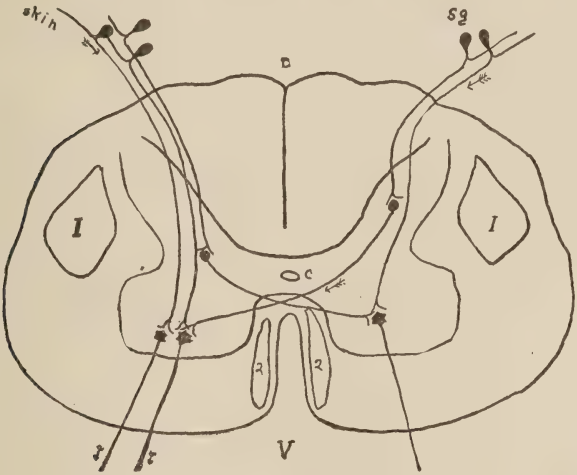


FIG. 28.—Cross-section of the spinal cord. The inner H-shaped figure gives the outline of the gray matter. The remainder is white matter. *D*, dorsal; *V*, ventral; *sg*, central ganglion; *c*, central canal; *1*, *1*, are crossed pyramidal tracts containing fibers from the pre-Rolandic area of the brain; *2*, *2*, are direct pyramidal tracts carrying the same type of motor nerve fibers from the brain. The crossed fibers cross from one side to the other of the cord in the region of the medulla. The direct fibers cross at lower levels. The arrows indicate the direction of the nervous impulse.

inherited and thus instinctive, or acquired and thus habitual. We shall canvass the factors underlying the formation of these associations later in the chapters on "Unlearned Behavior" and "Habit."

The Development of the Nervous System.—A glance forward to Figure 30 will convince the reader that if any key to the complexity of the human nervous system is available it should be

ultilized. The development of nerve structures in the evolution of organisms and in the embryology of the individual furnishes such a key. We have already seen the condition in protozoa, unicellular organisms (p. 50), where there is no structural differentiation of the system. The first important step for our purposes after this stage is the appearance of a diffuse nerve net such as is found in the jelly-fish. Impulses may start at any one of its sensory patches and pass in any direction to affect the muscles of the body and tentacles.

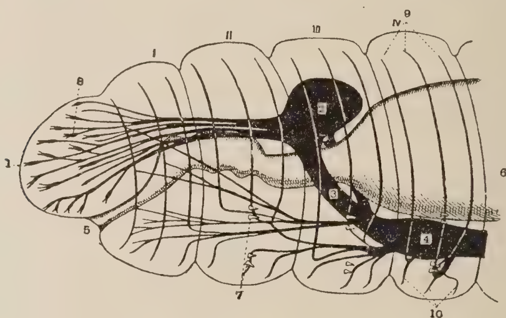


FIG. 29.—A lateral view of the nervous system in the anterior end of an earthworm (after Hesse from Shipley and McBride): 2, the brain or cerebral ganglion; 3, connecting bands of nerve tissue; 4, first ventral ganglion; 5 the mouth; 8, 9, 10, nerves.

Figure 29 represents a higher stage of evolution, the nervous system of the earthworm. In the anterior segment of the worm is a ganglion, or mass of nerve tissue, termed the brain. Below the alimentary canal lies the ventral nerve cord which duplicates in essentials of structure the spinal cord of man and other vertebrates to be described. Provisions exist in the nerve cord of the worm whereby afferent nervous impulses may pass out immediately as efferent impulses or whereby they may pass up or down the cord a greater or lesser distance. The ordinary locomotion of the worm involves primarily short association neurones, whereas the sudden contraction of the whole body upon injury is due primarily to the activity of long fibers. Yerkes has shown that simple maze-habits

established by normal worms persist even after the head has been removed from the body. Apparently the chief difference between the normal and the headless worm lies in the less variable behavior of the latter. The evolution of the nervous system from the worm to man involves the following changes fundamental to behavior: (*a*) an increase in the complexity of the head ganglion, or brain; (*b*) an increase in the number of long connections within the cord, making the cord more of a unit as opposed to the condition in the worm, where each segment is fairly independent; and (*c*) an increase in the mutual relations between brain and cord, a more complete unity of all nervous action.

The human nervous system is essentially a hollow tube much modified and enlarged at the anterior end. The spinal canal shown in Figure 28 is part of the inner cavity of the tube and is continuous with the four large ventricles, cavities, of the brain. The embryological development takes place in the following manner: Nervous tissue begins as a thickening in the ectoderm on the dorsal side of the embryo. This neural plate folds in, or invaginates, and closes over, thus forming the neural tube. At the anterior end three enlargements, primary vesicles, appear by an unequal thickening of the walls of the tube. From these three vesicles the brain develops by a series of outgrowths and flexions into the form to be described below. Along the main body of the tube outgrowths occur which develop into the spinal nerves and into the sympathetic nervous system. Our discussion will now deal with the structure of the adult nervous system and the functions of its various parts.

Divisions of the Adult Nervous System.—The nervous system is composed of two main divisions: the *cerebro-spinal system* and the *sympathetic system*. The essential topographical relations of the two are shown in Figures 30 and 31. The sympathetic system, which is intimately connected anatomically and physiologically with the cerebro-spinal system, is composed of the following parts: (1) a chain of ganglia lying ventral to and on either side of the spinal cord; (2) three or four large masses of nerve tissue called plexuses lying in the body cavity and in close connection

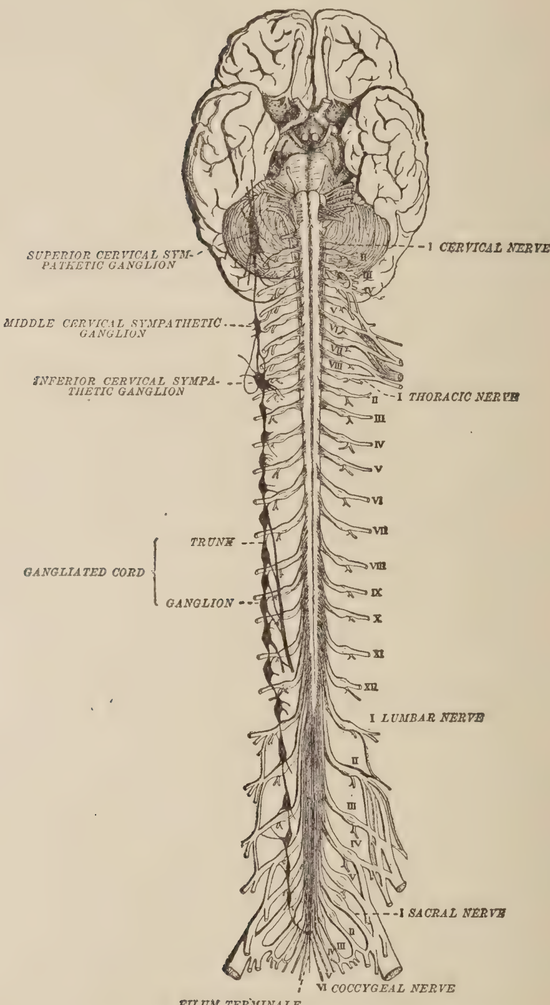


FIG. 30.—Ventral aspect of the major portion of the cerebro-pinal system, showing also one of the chains of sympathetic ganglia (from Morris). The numbers point out the 31 pairs of spinal nerves. The large mass of nervous tissue at the top is the cerebrum. The smaller dark striped mass is the cerebellum. The 12 pairs of cranial nerves are shown (unnumbered) above the spinal nerves.

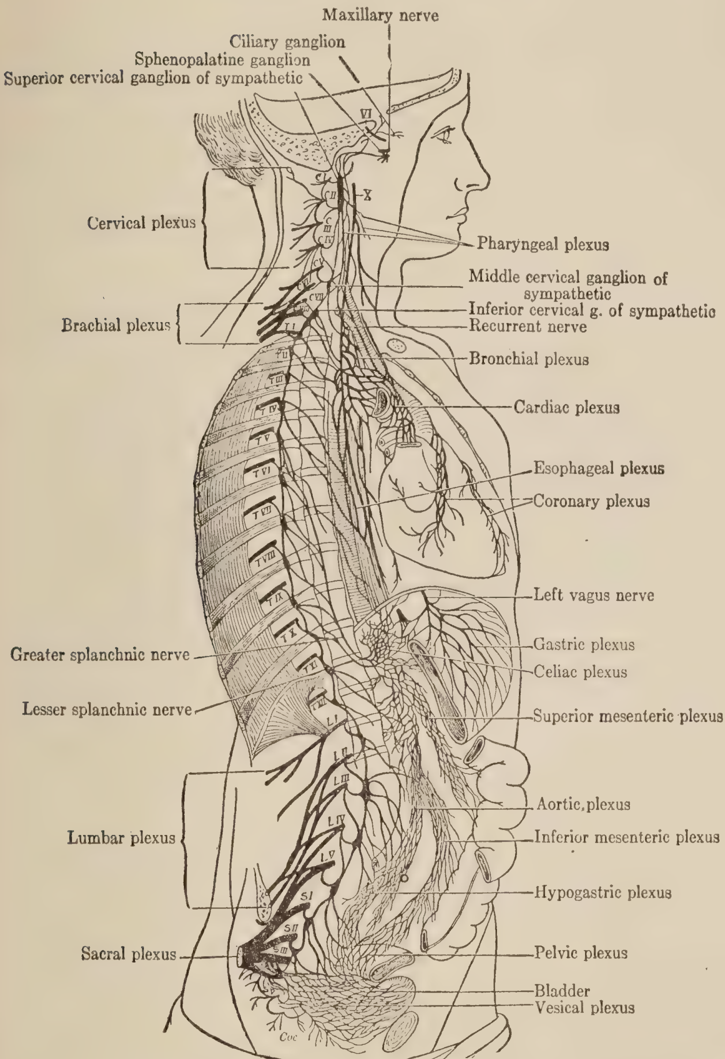


FIG. 31.—Showing the sympathetic nervous system in some of its widespread ramifications (after Schwalbe from Herrick). The Roman numerals again refer to spinal nerves (plus the VIth and Xth cranial nerves). The diagram also indicates the location of the chief parts of the nervous system with reference to the body in general.

with the organs controlled; and (3) smaller ganglia scattered throughout the organism, in the eye-socket, in the thoracic cavity, on the walls of the heart, and elsewhere. Its function is the control of the action of glands and smooth muscles, activities such as the secretion of saliva, the peristalsis of the alimentary canal, and the variations in the tension of the arterial walls. In addition afferent impulses come from all of the viscera to sympathetic ganglia and

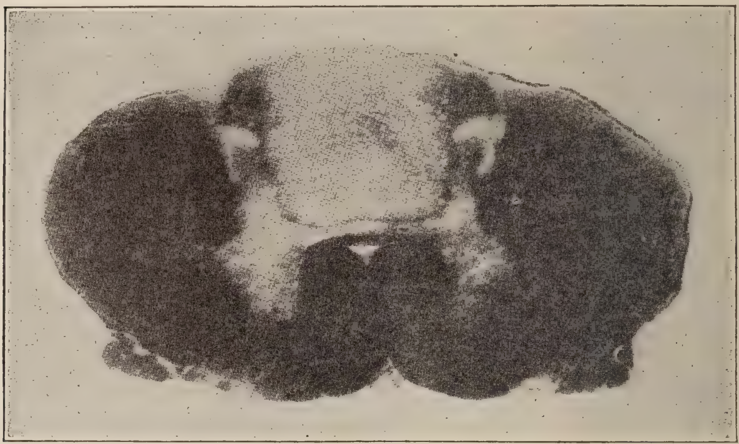


FIG. 32.—Degeneration changes in the spinal cord from tabes (from Jelliffe and White). Practically all of the dorsal part of the white matter has degenerated and is shown in lighter gray.

often go on into the spinal cord. Here they may be transferred and reach the brain, after which they control behavior with reference to organic sensitivity. It is probably in relation to the emotions, however, that the sympathetic system has its greatest significance for behavior. The cerebro-spinal system includes the central nervous system and the peripheral nervous system. The former includes the spinal cord and brain; the latter is composed of the cranial and spinal nerves.

The Structure and Function of the Spinal Cord.—Figure 28 has already made us familiar with the cord in cross-section and

with reflex arcs. A nerve impulse may come in over any one of the afferent fibers from some receptor in the skin, pass by association neurones to any other efferent neurone at the same level of the cord or at some other level, and from there go out to a muscle or gland. These afferent and efferent fibers at any one level of the cord are bound together to form the spinal nerves, sensory and motor, of which there are thirty-one pairs. The sensory impulses that come in over these nerves condition kinaesthetic (muscle, joint, and tendon), organic, and cutaneous sensitivity. Figure 32 illustrates a cross-section of the cord, showing extensive degenerations in the dorsal portion.

The function of the cord is: (1) to convert sensory impulses directly into motor impulses; and (2) to transmit impulses to upper or lower levels of the nervous system. We shall now indicate how these functions are performed by certain essential and typical structures. The cell-body of the first, the sensory, neurone always lies in the spinal ganglion,[1] while that of the motor neurone lies in the ventral or in the central part of the spinal gray matter. The gray matter of the cord is composed largely of cell-bodies and unmedullated fibers, the white matter consisting of medullated fibers passing up and down the cord. Fibers and cell-bodies having similar functions are grouped together both in the white matter and in the gray, forming, respectively, fiber tracts and columns, or *nuclei*. The only further detail we need mention is the location of the pyramidal tracts, crossed and uncrossed, which contain fibers originating from cell-bodies in the pre-Rolandic area of the cerebral cortex. Impulses pass down over these and produce movements of the skeletal muscles. All of these fibers finally cross to the opposite side of the body, so that the left side of the brain is connected with the right side of the body, and vice versa. Sensory impulses passing to the brain go over certain definite pathways also, but these latter need not claim our attention. Any lesion due to accident or disease in these pathways in the cord results in such characteristic

[1] A *ganglion* is any group of nerve-cells outside the central nervous system.

disturbances of movement and sensitivity as to enable the clinician to diagnose the location of the lesion fairly accurately. In locomotor ataxia, or tabes, for example, the germs attack the posterior columns of white matter (Fig. 32). As a consequence of the resulting loss of touch and kinaesthetic sensitivity, the individual is unable to control properly the movements of his feet and legs. Vision is therefore used as a guide, but even with this aid a characteristic gait is evident, caused by the absence of necessary sensory impulses.

The Medulla.—Figure 30 should be consulted in order that the student may have clearly in mind the mutual topographical relations of the parts of the brain, for we shall now deal with the second division of the central nervous system. The *medulla* is about one inch long and is a continuation of the spinal cord. Nerve impulses pass through it to the cerebrum and cerebellum as well as down it to the spinal cord. In addition it contains nerve centers[2] which control circulation and respiration. When the carbon dioxide content of the blood, e.g., becomes abnormally high, as in approaching asphyxia, this chemical condition acts upon centers in the medulla with the result that the heart-beat is increased in rate and respiration is accelerated and deepened. Both cerebro-spinal and sympathetic nervous systems are involved in this action of the medulla.

The Cerebellum.—The *cerebellum* is composed of two hemispheres connected by the pons and bound by many fibers to the medulla and mid-brain. The chief function of this division of the brain is the maintenance of bodily equilibrium. To this end sensory impulses are received from the skin, muscles, and joints, from the semicircular canals of the ear, and from the eyes. The stopping of any of these classes of nerve activity interferes tremendously with equilibrium. We have noticed it already in locomotor ataxia. It can be shown by closing the eyes and attempting to stand without swaying, or in laboratory work by extirpating the semicircular canals of animals. If the injury is as great as the total excision of

[2] The term *nerve center* applies to any group of nerve-cells in the brain which has a definite function.

the cerebellum, the animal is entirely unable to maintain its balance. Impulses from the cerebellum serve also to maintain proper muscular tonus (contraction). It is probable that all portions of the cerebellar cortex, or outer gray layers, have the same function. So far no evidence has been produced indicating that verbal responses can be correlated with, or directly conditioned by, nervous activity in this cortex.

The Mid-Brain.—The dominant structure of this part of the brain is the corpora quadrigemina (superior and inferior colliculi), whose function is that of visual and auditory reflexes. Sensory impulses coming from the eyes (retinas) and ears (cochleas) enter here into synaptic connections with many motor neurones to the face, eyes, and other parts of the body.

The Thalamus.—The thalamus is a large mass of nerve centers lying in the center of the brain. All sensory impulses go through some part of this structure before reaching the cerebral cortex, with the exception of certain impulses from the nose (olfactory membrane) coming over the first cranial nerve and arriving at the cortex by a different route. Clinical observations indicate that sensory impulses undergo much elaboration in the thalamus, probably in the way of association with other afferent impulses, so that impulses which reach the central cortex have already become complex and integrated. Studies of unilateral thalamic lesions by Head and Holmes have presented evidence that emotional behavior is controlled in many essentials by neural activity in the thalamus. Individuals with such lesions have excessive enjoyment of warmth or of concerts, for example, upon the affected half of the body. The evidence from this work further points to the general inhibitory influence of the nervous processes of the cerebral cortex upon those of lower portions of the brain.

The *corpus striatum,* a nerve center lying between the thalamus and the cerebral cortex, is another correlation center. Like the thalamus, it offers further opportunity for the elaboration of sensory impulses before they reach the cortex. In each case the sensory impulse may pass over a motor neurone originating in these

correlation centers and a reflex act result without involving the cortex.

The Cerebral Cortex.—The neural processes which occur in the cerebral cortex comprise the major part—if not all—of those

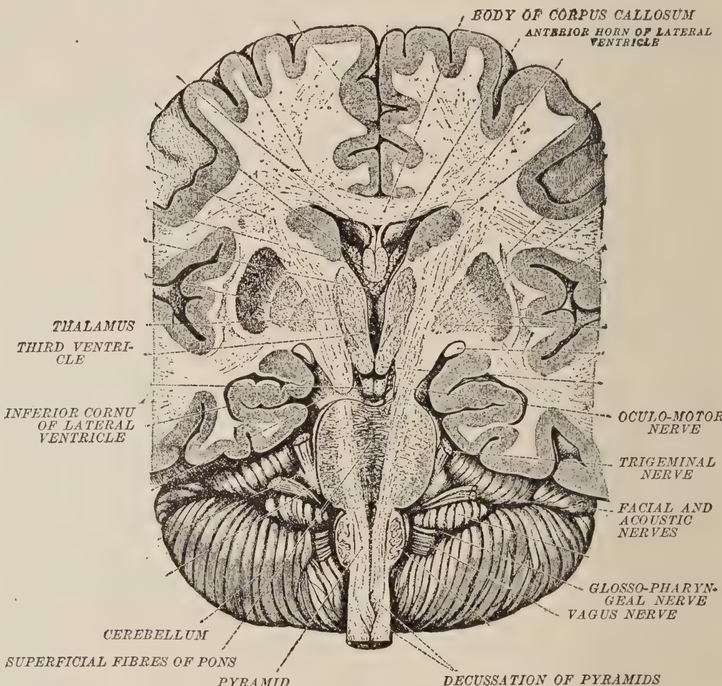


Fig. 33.—A vertical section through the brain (after Toldt, *Atlas of Human Anatomy*, by permission of Rebman Company, New York). Fibers are faintly indicated passing from the cord to various portions of the brain. The lateral portions of the cerebrum have been left out of the diagram.

physiological activities which are most directly correlated with language behavior. The remainder, if there are any, occur in the thalamus. The cortex is the highly convoluted layer (rind) of gray matter about 4 mm. thick which covers the cerebrum as a whole. Figure 33 shows this fact and also the topographical relations of

the cortex to the other nerve centers which we have been describing. Unlike the cerebellar cortex, that of the cerebrum is highly differentiated in function. Figure 34 names the primary lobes and

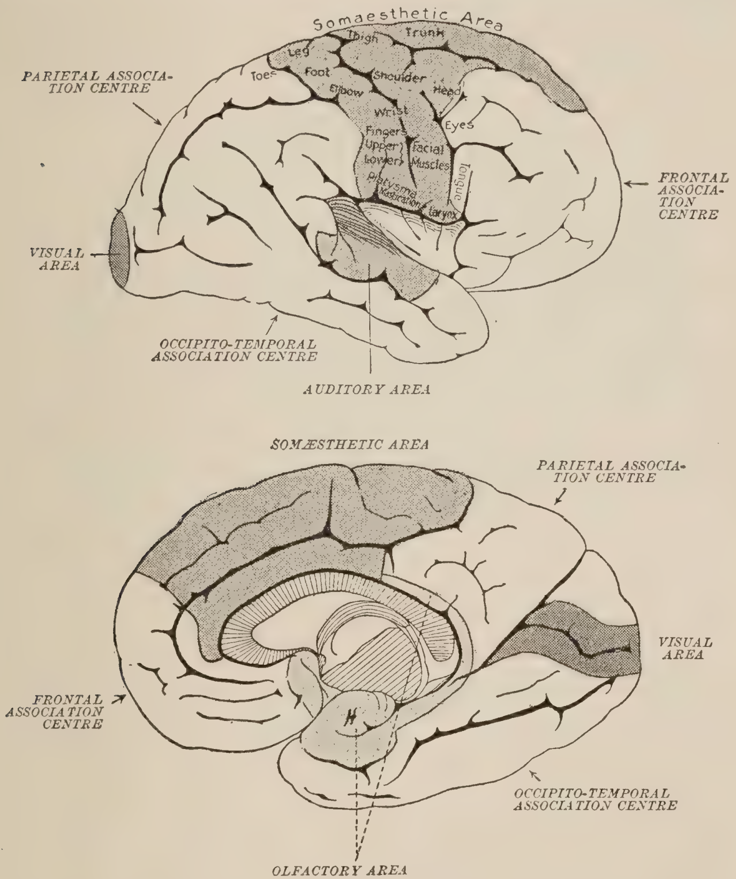


FIG. 34.—Diagrams of the two sides of the left cerebral hemisphere, indicating the localization of functions (from Morris). *Visual area* in occipital lobe; *auditory area* in temporal lobe; *olfactory area* in *H*, the hippocampal lobe. The *somaesthetic area* lies on both sides of the fissure of Rolando, the pre-Rolandic area being an area for skeletal movement and the post-Rolandic area receiving sensory impulses for the skin, muscles, joints, tendons, and viscera.

their accepted functions. To designate the occipital lobe as the "visual center" means that sensory impulses from the retina of the eye reach this part of the brain and that any disease or accident affecting it modifies primarily the visually controlled behavior. Figure 35 shows some important fiber tracts within the brain, in

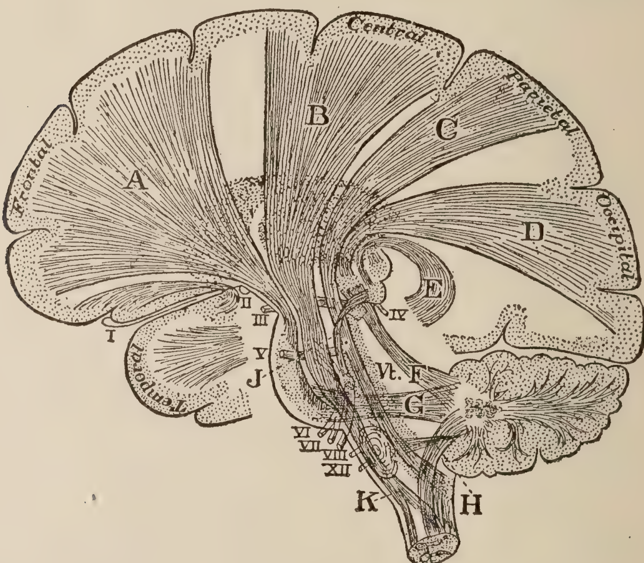


FIG. 35.—Some important fiber tracts in the brain (after Starr from Judd). The Roman numericals indicate the cranial nerves. The dotted mass in the center is the thalamus. Just anterior and dorsal is another mass, the corpus striatum.

addition to which are innumerable smaller ones connecting adjacent parts of the cortex.

The following are the chief methods that have been used in mapping out the localization of functions which were schematically presented in Figure 34: (1) The anatomical method is used in tracing the fibers from a given sense-organ to their ultimate cortical destination and from the motor areas to lower centers. Very im-

portant is the fact that degenerated nerve fibers stain differently from normal fibers and that fibers degenerate not toward but away from their cell-body. By experimentally sectioning certain tracts in animals and by observing postmortem the effects of lesions in man, it has been possible to construct fairly definitely the functional pattern of the cortex. In addition to this fiber-degeneration method, there is the method of mapping cell patterns. The cortex contains many different types of cells which vary in the patterns of their relative distribution from one part to another of the cortex. In illustration of this, Figure 36 shows a section from each of two well-marked cortical areas, the pre-Rolandic motor area and the optical area of the occipital lobe. (2) The physiological method attempts to formulate the function of a given brain area by noting the effect of its activity upon the behavior of the animal. Parts of the brain are removed and modifications in the animal's sensitivity and motor capacity studied. A variation of this method, as applied to the determination of the motor areas, involves the electrical stimulation of the exposed brain of an animal and the recording of those muscles which contract. Tests have been made on the exposed brain of man in certain cases, and results have here been obtained similar to those secured on monkeys and dogs. (3) The embryological method of Flechzig studies variations in cortical areas on the basis of the varying periods at which the axones acquire their medullary sheaths.

It is not to be thought that these individual areas of the brain function as would separate units—the point of view held by the phrenologists Gall and Spurzheim and their successors. When we refer to the superior convolution of the temporal lobe as the auditory center, we mean that it is the focus of cortical activity produced by impulses from the VIIIth nerve, for the brain is active as a whole and not in parts. Behavior at any one moment is complex and is regulated by neural activities which are widely spread throughout the cortex. An interruption of the association pathways from any primary sensory center with the consequent partial isolation of it from the rest of the cortex leads to marked behavior

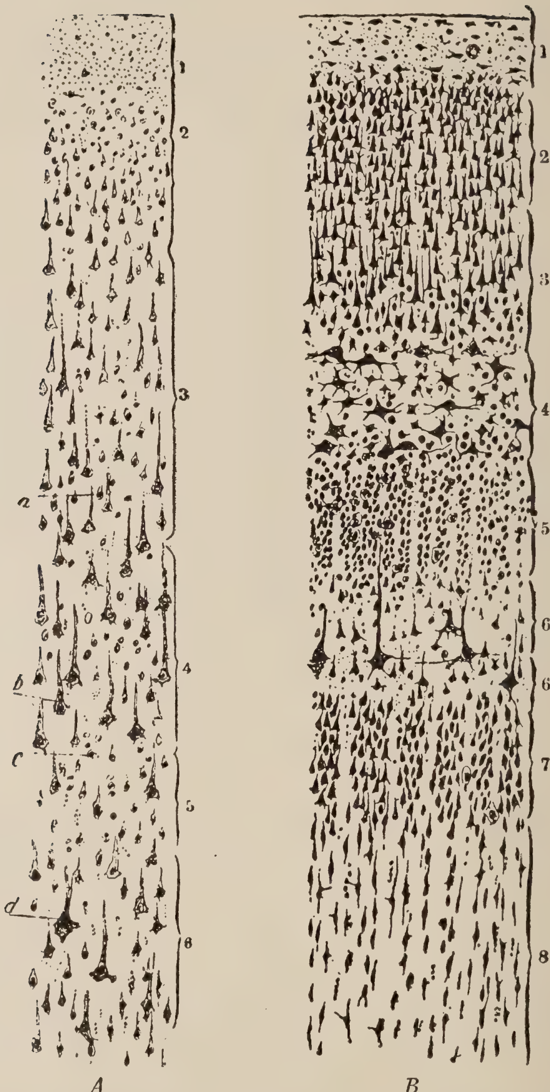


FIG. 36.—Sections from the cerebral cortex (from Quain after Cajal). The sections reveal great variations in cell pattern. *A* is from the pre-Rolandic area. *B* is from the visual area of the occipital lobe.

disorders termed *aphasia.* Inasmuch as the receptors and their primary reflex arcs are not affected, the subject does not lose his sensitivity. He can still respond to visual and auditory stimuli, for example, but he no longer makes the customary responses. He can, e.g., respond to the visual stimulation from his own house, but he often fails to make those responses which identify his own house as opposed to the houses of others. Where the motor centers of speech are the primary ones affected by the neural lesions—and this is the characteristic disturbance of aphasia—the subject loses all or many of his vocal-verbal responses. Should the loss be only partial, the complex responses are the ones chiefly affected. The subject may be able to respond with syllables or even words, but he cannot put these unit responses together in sentences as he formerly did.

The Cranial Nerves.—Twelve pairs of cranial nerves are given off from the brain, some of which are purely sensory, others purely motor, while others have both sensory and motor fibers. The points of origin from the external surface of the brain are shown in Figure 30. These nerves are numbered from I to XII, beginning at the anterior end of the brain. The names and functions important for us to know at present are as follows:

I	. . . Olfactory	Smell
II	. . . Optic	Vision
III	. . . Oculo-motor	Motor and sensory to eye-muscles
IV	. . . Trochlear	Motor and sensory to eye-muscles
V	. . . Trigeminous	Sensory from skin, mouth, and teeth
VI	. . . Abducens	Motor and sensory to eye-muscles
VII	. . . Facial	Taste on anterior part of tongue
VIII	. . . Auditory	Hearing and equilibrium
IX	. . . Glossopharyngeal	Taste on back of tongue
X	. . . Vagus	Motor and sensory to viscera
XI	. . . Spinal accessory	
XII	. . . Hypoglossal	

We shall study the functions of certain of these sensory nerves and their related receptors in much detail in the chapter on "Receptor Processes."

Important Groups of Conduction Paths.—In order to make the foregoing account of the nervous system significant it is necessary that the reader actually trace out the schematic pathways followed by nervous impulses in simple types of behavior. Suppose,

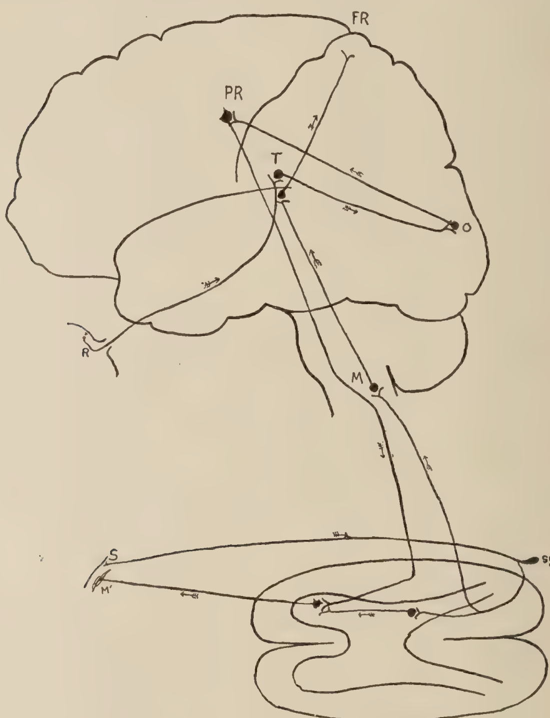


FIG. 37.—Probable pathway of a nerve impulse underlying a simple response. *R*, retina of eye; *T*, thalamus; *O*, occipital lobe; *PR*, pre-Rolandic area; *M'*, muscle; *S*, skin; *sg*, spinal ganglion; *M*, medulla; *FR*, fissure of Rolando.

for example, that I see an object, reach for it with my right hand, and then a sensory impulse is started, a part of which causes me reflexly to grasp the object and a part of which reaches the cerebral cortex. What is the neural pathway followed by these impulses? The impulse (Fig. 37) starts in the retina, goes to the thalamus,

and thence to the occipital lobe. The impulse now passes over an association neurone to the pre-Rolandic area, whence another neurone carries it to the anterior horn of the spinal cord at the level of the hand. Another neurone carries it to the muscles of the hand, and I have touched the object. The stimulation of a receptor in the skin starts an impulse over a spinal sensory nerve which enters the dorsal horn of gray matter. A part of the impulse passes into a cell in the ventral horn of gray matter on the same side and goes back to the muscle of the hand, and I reflexly seize the object. In the meantime part of the impulse has passed up the cord over one neurone and is then transferred to another in the medulla, which carries it to the thalamus. From here a third neurone carries the impulse to the post-Rolandic area of the cortex, from which numerous other connections may be made.

In this fashion the reader can trace out many probable paths over which nerve currents pass, conditioning particular instances of behavior. It is important to remember the following points, which have already been presented, in order to make the constructions with the least difficulty: (1) the names of the lobes of the brain and their functions must be memorized; (2) all sensory impulses pass through the thalamus, save certain olfactory ones; (3) many motor impulses conditioning action originate in the pre-Rolandic area; (4) association neurones connect any two or more parts of the cortex; and (5) in the spinal cord sensory impulses always enter on the dorsal side and motor impulses always go out from the ventral side.

The hypothetical nervous activity diagrammed in this manner differs from what actually occurs largely in its greater simplicity. Many neurones are involved wherever one was mentioned in the preceding, and many associated neurones are active in the cortex, where we have mentioned but few. Wherever it is possible, as our account proceeds, we shall describe the probable neural processes concerned in the different activities. The student must remember throughout his work to correlate of his own accord, so far as possible, neural activities with the various phenomena of behavior.

REFERENCES

BING, R. *Compendium of Regional Diagnosis in Affections of the Brain and Spinal Cord* (3d ed., St. Louis, 1927).

BROUWER, B. *Anatomical, Phylogenetical, and Clinical Studies on the Central Nervous System* (Baltimore, 1927).

DUNLAP, K. *Psychobiology* (Baltimore, 1914).

HERRICK, C. J. *An Introduction to Neurology* (4th ed., Philadelphia, 1927).

HOWELL, W. H. *Textbook of Physiology* (8th ed., Philadelphia, 1922).

LICKLEY, J. D. *The Nervous System* (New York, 1912).

PARKER, G. H. *The Elementary Nervous System* (Philadelphia, 1919).

RANSOM, S. W. *The Anatomy of the Nervous System* (3d ed., Philadelphia, 1927).

CHAPTER II

UNLEARNED BEHAVIOR

Introduction.—Human behavior may be divided into learned and unlearned behavior upon the basis of its genetic history during the individual's lifetime. The division between the two classes of behavior is not sharp, because probably all forms of behavior are subject to some modification through training and because all forms of learned behavior have a larger or smaller nucleus of unlearned responses. In a later section of the present chapter we shall discuss the evidence which is available to support the theory that some behavior is inherited. Before weighing this evidence we shall make a brief study of the two forms of activity, reflex action and instinct, which are commonly recognized as unlearned behavior.

Definition of Reflexes.—In the topic of reflex action we are to examine the elementary mechanics of behavior. All behavior seems to be a combination, more or less complex, of the relatively simple activities of muscles and glands. Our brief examination is therefore the necessary prologue to the understanding of the more complicated forms of response termed instinct and habit. *A reflex act is a simple inherited mode of response controlled by the nervous system.* This definition rules out all responses of organisms devoid of nervous tissue. Such responses are *tropisms.* It also rules out those responses in animals with nervous systems where the activity is initiated directly by chemical means, as, for example, the case in man where the presence of pancreatic juice in the intestines stimulates the glands there to pour forth their secretions. These cases are also tropisms. The part that is inherited is the synaptic connection which finally determines the nature of behavior. Figure 28 represents two reflex arcs on the left side of the spinal cord. The motor neurone of the one arc may lead to the muscles that extend the hand, and the other motor neurone may lead to flexor muscles

of the hand. The sensory neurone, which has synaptic connections with each motor neurone, comes from the skin, where it can be stimulated by an injurious object. When such an object sets up a sensory nervous impulse, this impulse passes immediately out over the former of the two neurones by virtue of the relatively low resistance of this synapse, and the object is dropped. It is this low resistance at the synapse which is inherited. Even in the extremely simple case that we have taken, however, the activity is not confined to one reflex arc. No one reflex arc acts independently of the other reflex arcs. In our present instance, before the hand could be opened (extended), the muscles which closed (flexed) it had to relax. In other words, the sensory impulse not only excited one group of muscles; it also inhibited the antagonistic group. Even the simplest activity therefore involves a co-ordination of reflex arcs. The mechanism of inhibiting muscle *F* is as much inherited as that for exciting muscle *E*. It is primarily for this reason that no sharp distinction can be drawn between reflex action and instinct.

The reader should not infer from the preceding description that all reflexes occur through the spinal cord. The brain is particularly rich in reflex centers. Two important ones were noted in chapter i, the medulla and the mid-brain.

Types of Reflexes.—We have seen in Part I, chapter i, that reflexes may be classed as *conditioned* and *unconditioned* upon the basis of the presence or absence of the effects of training. Two other types of classification remain to be mentioned here. *Allied* and *antagonistic* reflexes constitute one of these classes. Allied reflexes are those which occur simultaneously and which facilitate each other. A dog starting to scratch, e.g., must shift his weight to three legs. The reflexes so involved are allied in relation to the scratch reflex. Antagonistic reflexes are those which cannot occur simultaneously and which inhibit each other. Walking and running are two such cases, inasmuch as they involve mutually incompatible forms of behavior. The activities of paired flexor and extensor muscles form another example. One cannot extend the fingers at the same time that he is closing them. In such cases the

activity of the flexor group involves an inhibition of the extensor group, and vice versa. The remaining type of classification divides reflexes into those which are complicated with verbal responses and those which are not. The former group are, typically, reflexes controlled by the cerebro-spinal system. The latter group are, typically, reflexes controlled by the sympathetic nervous system. *Verbally complicated reflexes* are those which through training are, or may be, accompanied by verbal responses. The knee-jerk, the wink, sneezing, and swallowing are examples of verbally complicated reflexes. The sensory nervous impulses set up in these reflexes may cause contractions in the vocal musculature. Verbal responses often produce sounds which result in nervous impulses from the ear, and they always result in kinaesthetic nervous impulses from the vocal musculature. In the verbally complicated reflexes either the auditory or the kinaesthetic impulses set up by the verbal response may arouse the reflex. *Verbally non-complicated reflexes* are those reflexes which cannot arouse verbal responses, even after training, and which cannot, in their turn, be aroused by the immediate and direct sensory consequences of the verbal responses. To this class belong such reflexes as glandular secretions, activities of the iris and ciliary muscles of the eyes, and the contractions of the heart muscles.

Figure 38 presents a diagram as an aid to the understanding of the verbally complicated and the verbally non-complicated reflexes. We shall use the knee-jerk for purposes of illustration. A stimulus applied to the receptor, *R,* sends impulses across neurone 1 to the effector at *E.* The contraction of the effector stimulates receptors in the effector, and a nervous impulse passes over neurones 3, 4, and 5 to the vocal effectors, *Ve.* When these effectors are thrown into activity, the receptors which lie in them are stimulated, and nervous impulses pass over neurones 6 and 7 and so over neurone 2, with the consequent arousal of the effector, *E.* If the activity of the effector, *Ve* makes a sound, the ear, *Ea,* is stimulated and nervous impulses pass over neurones 8 and 9. The activity of the verbally complicated reflex differs from the situation in the

conditioned reflex by the presence of neurones 3, 4, and 5. In a conditioned reflex it is essential that a new stimulus arouse the old

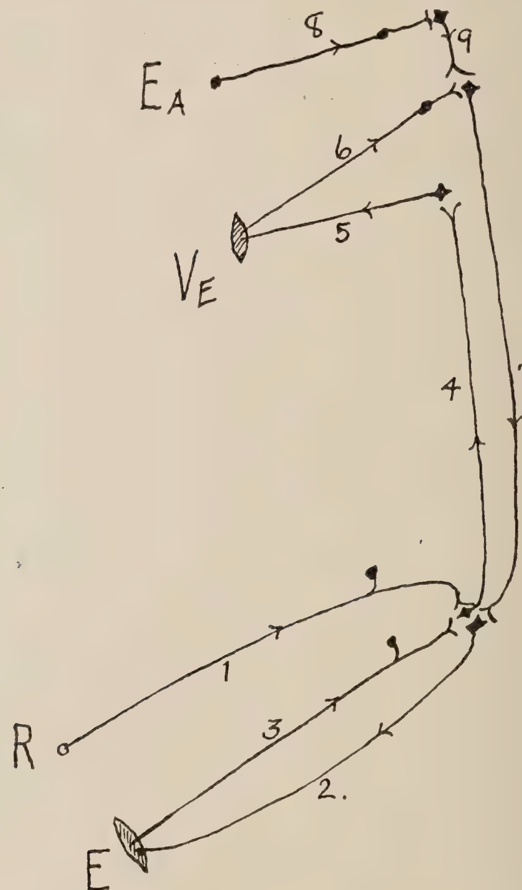


FIG. 38.—A schematic diagram of verbally complicated and verbally non-complicated reflexes. The figure is described in the text.

response. This is shown in Figure 38 by the afferent pathway, 6 and 7, from *Ve*. When *E* is active as a result of impulses from *Ve*,

the response is again a conditioned reflex. In a verbally complicated reflex, the reflex activity arouses a verbal response. Reflexes of the type of the heart beat, although they arouse afferent impulses, do not send these afferent impulses to the vocal musculature, nor can they be trained to do so. These reflexes are, therefore, classified as verbally non-complicated.

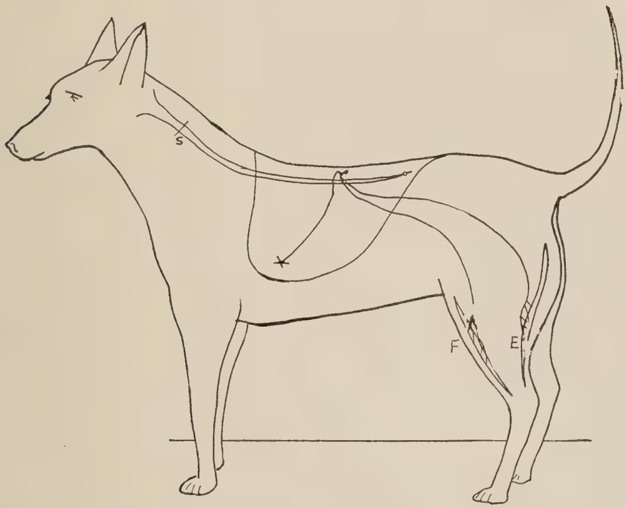


FIG. 39.—A spinal dog. The figure also indicates reflex arcs from the point x in the saddle-shaped area to the flexor (F) and extensor (E) muscles of the leg. The approximate location of the spinal section is shown in the cervical region (S).

Typical Phenomena in Reflex Action.—Most of the experimental data that we have on the simpler reflexes come from a study of spinal animals. A spinal dog, e.g., is one whose spinal cord has been transected, or cut across, just below the medulla, thus freeing the reflex activities controlled by the cord from the influence of the brain. In animals like the dog the reflex functions of the cord persist unimpaired by the operation. In the dog the scratch reflex has been most thoroughly studied (Sherrington). If any point in the saddle-shaped area of the spinal dog shown in Figure 39 is stimulated, the hind leg on that side is alternately

flexed and extended in the typical scratch activity. Only allied harmonious reflexes are active at any one moment. The rate of this reflex is constant (4.5 beats per second) no matter what the intensity of the stimulus. The scratch rhythm proceeds practically unmodified by variation of the rhythm of the stimulation of the skin. This partly depends on the fact that each reflex has a *refractory period* during which, even apart from fatigue, it cannot be fully re-excited. The refractory phase is very similar to inhibition, and in the case of the scratch reflex depends upon changes in the central portion of the reflex arc. If the intensity of the stated stimulus is gradually increased, the phenomenon of *spread* occurs, i.e., more and more reflexes are aroused, due to the irradiation of the nervous impulses in the cord, until the whole dog is active. Furthermore, if two points of the saddle-shaped area are stimulated simultaneously, each stimulus by itself being too weak to arouse a response, the reflex will nevertheless appear as a result of the *summation* of the nervous impulses. Other additional facts have been brought out that are of importance in securing a comprehensive view of the behavior mechanism. Each reflex, for instance, has a *latent time,* i.e., a period intervening between the application of the stimulus and the appearance of the response. The length of this latent time will vary from .002 to .2 second, depending on the intensity of the stimulation. Sherrington has found that a reflex arc is just as ready to conduct, i.e., that it responds as quickly, when it is inactive as when it is active at the moment of stimulation. *Fatigue* also influences reflex activity. Again, other things being equal, the protective reflexes—those aroused by injurious, noxious stimuli—have *the right of way* over other reflexes. At any one moment, for example, contact with the floor tends to arouse the reflexes in the dog which give him his upright position. A painful stimulus, breaking in upon this, immediately gets control of the muscles of the leg and produces a protective reflex activity.

Two of the most important phenomena of reflex action are *facilitation* and *inhibition.* Sometimes nervous impulses facilitate, help, each other, and sometimes the relationship is one of inhibi-

tion, hindrance. Yerkes, e.g., found that he could secure a muscular contraction in a frog's leg by tapping the frog smartly on the back of the neck. When an auditory stimulus was given with the tap, the contraction of the leg muscles was greater. Inhibition is excellently shown in the reciprocal activity of antagonistic muscles. The activity of flexor muscles, e.g., is accompanied by an inhibition of the extensors, and vice versa. The mechanism underlying facilitation and inhibition is not clearly understood, although examples of the phenomena are numerous. The cerebral cortex exercises a marked inhibitory effect upon the lower nerve centers, and by so doing contributes to the regulation of behavior.

It is important in the present connection to relate the factors emphasized by Sherrington in his studies on the spinal dog to those other factors to be discussed in chapter vii under "Conditions Determining Dominant Behavior" and under the "Conditions of Habit Reinstatement," and to those factors discussed in chapter vi under the topic "The Fixation of Arcs in Habit." We wish in the present connection to say the following: Certain synaptic connections leading to the effectors are more open than others by virtue of inheritance, while practice within the lifetime of the individual reduces the resistance of other connections. These conditions governing behavior are relatively permanent over long periods of time, while the factors listed in the foregoing paragraphs, and certain of the facilitatory and inhibitory conditions, with the exception of "right of way," vary from moment to moment. This is essentially true also to the extent that behavior is partially determined by the behavior which has preceded, for "preceding behavior" is always a variable and indeterminate factor.

Resulting View of Behavior.—On the basis of these observations, how are we to describe the behavior of the dog or other animal at any one moment? Each animal has a definite limited number of muscles supplied by a limited number of motor nerves. All types of behavior, all forms of action, must use this single motor system. At any one moment eyes, ears, nose, and skin are sending sensory impulses in to the central nervous system. Here they must

compete for the control of the motor system. Which impulse shall win out will depend partly upon the interrelation of the factors we have just mentioned: refractory period, spread, summation of stimuli, latent time, fatigue, inhibition and facilitation, and the "right of way." A slight variation in any one of these factors may be sufficient to give control of the muscles to the eyes as opposed to the ears. This selection and determination of behavior are finally decided at the synapse on the basis of varying resistances to the passage of competing nervous impulses. This determination of behavior by synaptic connections we shall find exemplified in our present topic, instinct.

Definition of Instincts.—*An instinct is an inherited co-ordination of reflexes, i.e., a co-ordination which is predominantly unlearned.* The two forms of inherited response, reflexes and instincts, shade into each other, with complexity the chief difference. Popularly the term instinct—fear, anger, etc.—is applied to those particular inherited responses which are so well defined and prominent in the life of the individual as to influence the behavior of other subjects.

When we refer to instinct as an inherited co-ordination of reflexes we are stressing the fact that what is inherited is the particular combination of reflexes. Anger in a man, if uncontrolled, involves the clenching of the fists, a threatening attitude, and changes in the facial muscles, in breathing, and in the heart-rate. If he strikes, that act is the stimulus for the next blow, and in this way a regular chain of activity, characteristic of the species, is set up. When we speak of the inherited co-ordination of reflexes in a bird we may have in mind the following performance in nesting: The bird picks up a straw, flies to a limb, deposits it, and returns for another. This behavior is repeated until several straws are accumulated, whereupon arrival at the nest causes the bird to execute certain turning movements by means of which the nest is shaped. The completion of the nest stimulates the egg-laying mechanism. The presence of eggs leads to brooding and in a similar manner we

might trace other co-ordinations of reflex actions which are characteristic of birds of a given class.

In any particular case the only practical criteria for determining whether an act is an instinct or not are: (1) the relative perfection of the response on its first appearance, and (2) the universality of the response among members of the same species. These criteria enable us to pick out the instincts from such a list of activities as: typewriting, swimming, tennis-playing, nest-building, honeycomb-making, the killing of mice by kittens, the provisioning of the nest by wasps, the singing of birds, and the pecking of chicks. From this list we can at once discard typewriting and tennis-playing. Neither of these forms of response appears at the start full-grown, but each is built up by training. Neither, moreover, is characteristic of all members of any species. With swimming we hesitate. Probably all people and all animals of certain species when in water over their depth execute certain characteristic swimming or floundering movements. To this extent we have an instinct—an inherited form of behavior. To the extent that the swimming is not perfect, but is improved with practice, we have not an instinct but a habit. Which of these terms we shall apply, instinct or habit, depends upon the relative amount contributed to the response by heredity and by practice. Many of the foregoing responses are instinctive—nest-building, honeycomb-making, the pecking of chicks, etc. By this we do not mean that they are uninfluenced by practice or that they appear in unvarying form; we only mean that the inherited characteristic predominates. The following description of experimental data on instincts will serve further to clarify this point.

Some Experimental Studies of Instinct.—Practically all studies of instincts, in the popular sense of that term, have been made upon infrahuman animals. (We should not forget, however, that breathing and circulation are instincts in the technical sense of that term, and that these have been extensively studied in man.) There are two chief reasons for this: (1) animals are more readily controlled from birth, and so make more convenient study material,

and (2) man's responses are so deeply influenced by custom and habit that it is a rare instance when an instinctive response breaks through in anything like its original form and vigor. This last fact is put to particular use in psychoanalysis, as we have already seen. In addition it has given rise to two contradictory statements. One is that man has more instincts than animals and that their interference is what gives the highly varied aspect to his behavior. The other is that man has no instincts in the true sense of the word. The former view is probably much nearer the truth.

1. *The pecking of chicks.*—A good example of this experimental work is the analysis of the pecking instincts in chicks, published in 1911 by Breed. He undertook the problem in order to determine from the study of a simple, easily controlled response how perfect a particular instinct is at its first appearance and just how much development takes place after the first performance. The pecking response (the terminology of Spalding and Morgan being followed) was divided into three parts: striking, seizing, and swallowing. The chicks were hatched in an incubator and then kept in a dark basket prior to the beginning of the tests. After the first day's test the chicks were returned to the lighted brooder, from which they were taken each subsequent day for a test of their proficiency at that time. For the test the chick was placed upon a smooth black table-top upon which were a few grains of food. In pecking the chick might miss the grain; or strike it, but not seize it; or seize it, but not swallow it; or success might crown its efforts and the grain be swallowed. Fifty trials were given each day. Figure 40 shows how the chicks progressed from day to day. Curve 1 represents the decrease in errors of striking with increase in age of the chick. Curves 2 and 3 indicate similar decreases for errors in seizing and swallowing, respectively. Curve 4 shows the increase in the number of perfect responses as the chick increases in age. We may thus see graphically that the chicks, starting out with only 15 per cent of the responses perfect, reached an average of 84 per cent. Not all of this increase in efficiency, however, is to be credited to practice, or habit, as one might suppose at first thought. Un-

doubtedly as the chick grows older there is a maturation, not only of the bodily structure in general, but also of the nerve centers (synaptic connections) which control the instinct, so that a part of the increase in efficiency is due to the growth of the instinct as a result of strictly inherited tendencies.

Studies made by Shepard and Breed, Bird, and Moseley on chicks whose pecking has been artificially delayed throw light upon this problem. Figure 41 shows the results secured by Shepard

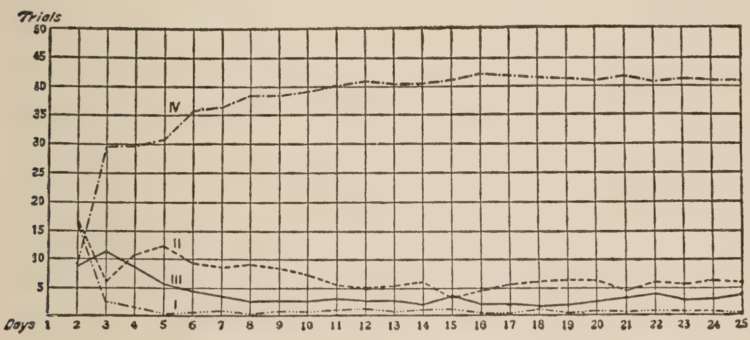


FIG. 40.—Graphic records of data secured by Breed in his study of the pecking instinct of chicks. The figure is described in the text.

and Breed. Chicks were kept from pecking for various intervals, some for three days, some for four days, and some for five days, and were then tested. During the delay they were fed artificially. All of the curves for these delayed chicks began below the normal curve, but caught up with this normal curve after two days' training. Although the number of subjects used was too small to make the curves reliable as representative curves for the conditions studied, the conclusion that maturation has made possible the rapid initial rise is very strongly suggested.

Moseley, working with a much larger number of chicks, secured results on delayed animals quite different from those of Shepard and Breed. The curves for her results are shown in Figure 42. There is good reason for believing that the slow improvement of

the delayed chicks was due to the interference of habits established during the period of artificial feeding.

Bird has secured results which indicate that maturation will not enable the chick to reach normal accuracy if the number of pecks per day is limited to twenty-five. Under these conditions the chicks improve normally for a few days, and then the records remain about constant until the amount of practice is greatly increased, whereupon the curves again rise until the reactions of normal chicks are approximated. Bird has also compared chicks tested

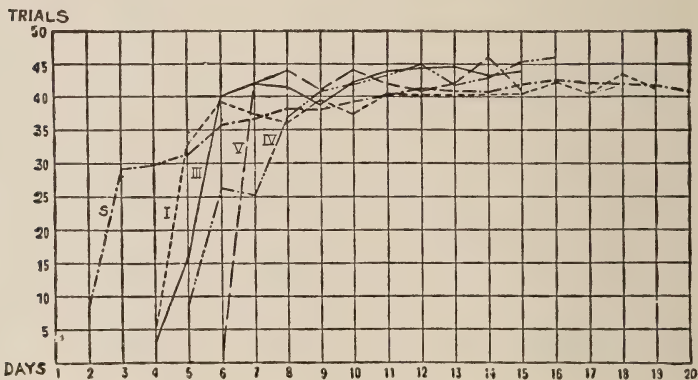


FIG. 41.—The development of the pecking instinct with normal conditions (*S*) and after delays of 3 days (I and III), after 4 days (IV), and after 5 days (V), *S* is based upon 21 chicks; I, upon 4; III, upon 6; IV, upon 3; and V, upon 1 (from Shepard and Breed).

eight hours after hatching and again when twenty-four hours old with chicks that pecked only after they were twenty-four hours old. In each case the better records were made by the older groups of subjects.

It seems possible to conclude from the various studies that the improvement of pecking behavior is accomplished partly by practice and partly by a maturation, which may be either a general physiological development or a specific growth of nerve centers, or both. This rôle of maturation may be blocked by interfering habits, as indicated in Moseley's work.

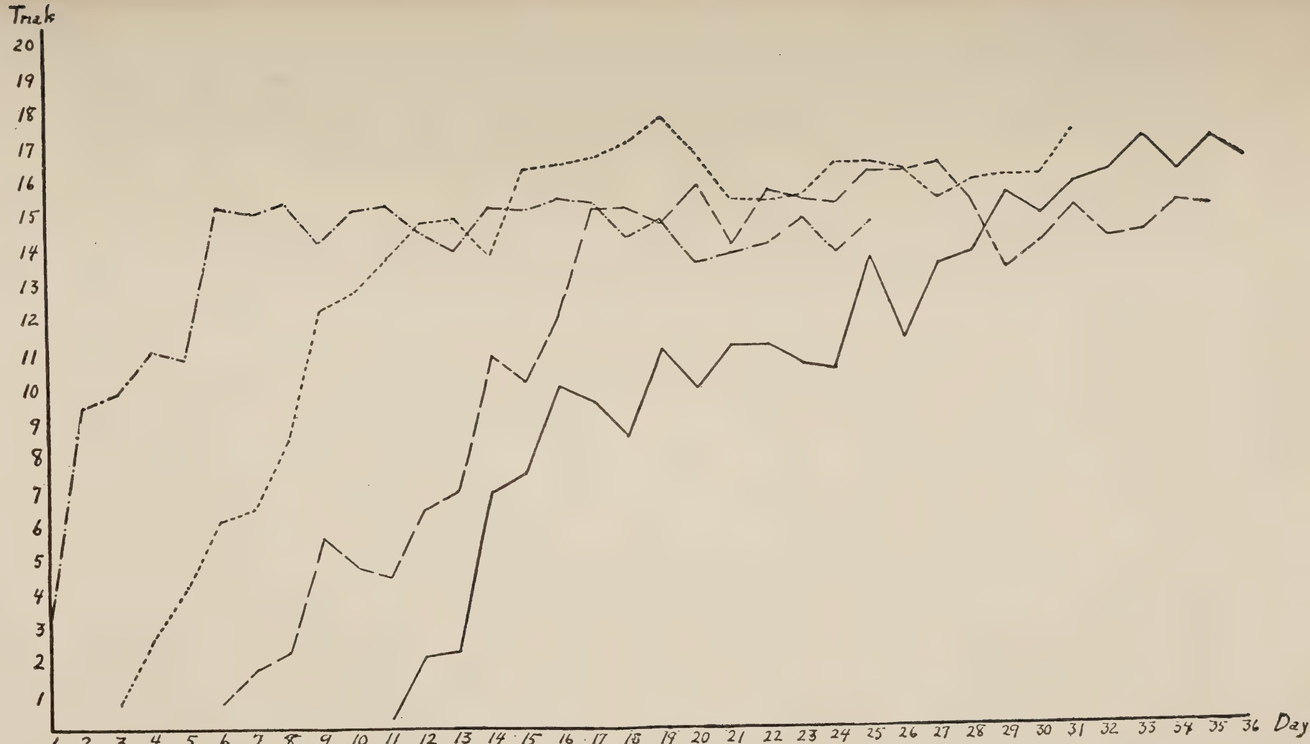


FIG. 42.—Curves for response 4 in the normal, the three days' delay, the six days' delay, and the eleven days' delay groups (after Moseley).

Carmichael has secured evidence bearing upon the rôle of maturation through the study of the swimming movements of the embryos of *Amblystoma punctatum.* Coghill has carefully worked out the reflex arcs which control these swimming movements and has correlated the appearance of these movements with the neural development, and Carmichael followed up this work by placing embryos in an anaesthetizing solution and allowing them to develop under conditions where they could not respond to external stimulation and where they made no responses. These anaesthetized animals were then placed in fresh water, and allowed to recover, after they had reached an age when normal embryos would be manifesting swimming movements. After recovery the animals respond to stimulation. We are, therefore, justified in concluding that the reflex mechanisms had developed in the animals without being influenced by external stimuli or by practice. Maturation and practice in the normal animal go hand in hand, but it is possible under experimental conditions to allow maturation to play the major rôle in the determination of behavior.

2. *The instinct of vocalization in birds.*—Studies by Yerkes and Bloomfield on the instinct to kill in kittens (p. 54) have indicated that certain inherited synaptic connections function independently of imitation and social example. In the following study by Conradi (1905), on the other hand, we find an equally certain case of instinctive activity and an equally certain influence of social factors (the stimulation of the bird by the songs of its associates) on the development of this activity. From this study and from that of Scott and Witchell it seems certain, moreover, that the call notes of birds are the primitive vocalizations, and are more uniformly inherited than the tendency to sing, which is present in addition in many birds. The mechanisms for vocalization are inherited, but the manner in which they shall function is determined largely by environment. This is illustrated by the fact ascertained by Scott that Baltimore orioles when kept alone and free from other birds developed a novel song of their own rather than the song characteristic of their species. Conradi's work illustrates the same point. He secured

some young sparrows from the wild and placed them either under the care of a mother canary or in the room with canaries. Some developed the sparrow call note, and in addition all learned more or less thoroughly the songs of the canaries with whom alone they all associated. I may quote one observation:

On September 26, when the sparrow was a little over three months old, he was for the first time observed to give a trill. It was short and musical and was given a number of times in succession. These short trills were at first only rare but they increased in frequency during the year. When he gave them he would sit still on his perch and give them one after another very modestly. Now (Dec., 1904) he gives short trills interspersed with other notes, punctuating the whole by turning complete circles and semi-circles on his perch.

None of these sparrows ever had the characteristic call note of the wild species, but by and by adopted those of the canary. They imitated the canary perfectly except that their voice did not have the musical finish.[1]

When removed from the canary environment they soon lost the canary song, but reacquired it on being again placed with those birds.

3. *Some instincts in the human infant.*—Watson has published (1919–21) one of the few experimental studies where man has been the subject. In the present instance infants varying in age from birth to twelve months were studied under laboratory conditions. We may leave unnoticed the careful observations upon such simple responses as those of grasping, sucking, right- or left-handedness, and sitting, and turn our attention to the essential points established concerning the more complex responses. Only three major forms of unlearned behavior were discovered in infants during the age-period in question. (I) There is a form of response involving catching the breath, clutching with the hands, sudden closing of the eyes, puckering the lips, and sometimes crying. Crawling away from the stimulus and sometimes hiding the face are added to these later in the period. The native stimuli for these responses are *the*

[1] E. Conradi, "Song and Call Notes of English Sparrows When Reared by Canaries," *Amer. Jour. Psych.*, XVI (1905), 197.

sudden removal of support and *sudden, loud sounds.* The behavior is not aroused by the dark, by animals, by fire, or by furry objects. This stimulus-response situation is given the name of *fear.* (II) There is another unlearned form of response in which the infant's body stiffens, the arms and legs thresh about, the breath is held, and crying or screaming may appear. The only native stimulus discovered for this complex behavior was *the hampering of the infant's movements.* This stimulus-response situation is termed *rage.* (III) The third unlearned form of response discovered includes smiling, the cessation of crying, extension of the arms, gurgling, and cooing. The stimuli here were not carefully determined, but were observed to include tickling, stroking the skin, gentle rocking, and lying upon the stomach across the attendant's knees. The stimulus-response situation here concerned is given the name of *love,* or *affectionate behavior.*

The Permanent Character of Instincts.—In spite of frequent opinions expressed to the contrary, there is no clear evidence that instincts in man and the higher animals are "intrinsically transitory." Not all instincts are present at birth. Breathing, sucking, swallowing, fear (possibly), and others are, it is true; many appear later, with the sex and parental instincts coming last. Once these forms of behavior have appeared, however, once the nerve centers which control them have matured, there is no good reason to believe that the organism ever loses them. Many instincts of infancy and childhood, such as sucking, playing, and grasping may be suppressed or transformed, and hence be apparently absent in later life. In many cases, however, the behavior will appear upon a representation of the proper stimulus, and in other cases the instinct will be found active as an integral part of some other form of behavior.

The Modification of Instincts.—Most, if not all, instincts are variable and not strictly rigid and mechanical. Probably none run their course in the same manner time after time. Much of this variability of inherited forms of behavior—which has been found even in the *Protozoa*—is due to internal physiological conditions of a

temporary nature, i.e., fatigue, satiety, etc., which modify, or for the moment inhibit, all or part of the instinct. Variability, however, as found in those animals that profit by training, is a matter also of permanent status. The basis of whatever variability there may be is to be found in the changed condition of the synapses controlling the final motor pathways to the muscles and glands. Inasmuch as instincts depend upon the proper functioning of total reflex arcs, the modification of instinct may occur either on the receptor (stimulus) side or on the motor (response) side, or on both. In each case the process is one of learning and habit-formation. Modification on the receptor side is illustrated by the fact that at one period of life I may fear "being on high places," while at a later period this stimulus no longer arouses fear. Or the situation may be the reverse. Objects that I do not fear at one period may come to arouse intense fear by virtue of my contact with them. On the motor side the instinct may be modified by training so that at one period of life anger, for example, is manifested in quite a different manner from that of its later form. The modification need not be, but often is, in the form of a total inhibition of external movements. And in some individuals the "control" of instinct may be so thorough that no stimuli met in the ordinary course of events can call forth a visible disturbance like anger or fear, or even arouse internal disturbances that can arouse verbal behavior. Such a person may be termed "cold-blooded," "unsympathetic," and the like.

As these statements imply, the facts of the last paragraph are of tremendous social and individual import. Because other peoples or classes do not respond to the same objects as we, we ordinarily tend to deny that they possess the power to respond. The fact that a savage does not react with shame at the absence of clothes does not mean that that form of behavior is lacking, for the same savage may be greatly shamed by the loss of his customary string of beads. As new customs arise, new stimuli take the place of the old in eliciting behavior. Ribot and McDougall have well pointed out these facts. What arouses admiration or love in one class may arouse disgust in another. The process of educating (in the broad sense) and

socializing an individual consists largely in determining for him, and in training him to accept, the approved stimuli for behavior. With development the instinct may be set off by more and more subtle stimuli. (This is the same principle exemplified by the conditioned reflex of an earlier chapter.) It does not take actual bodily injury to make one angry, for one may grow angry at an insult, at an attack on one's friend's honor, at a criticism of one's ideals. The ability to react to these more subtle stimuli makes one of the chief differences between man and animals and between man and man. The animal's instinct of anger and defense has only sensory stimuli, while man's instinct has in addition the stimulus of symbolic processes. The hope of a democratic social group lies in the ability of the majority to react to these less obvious stimuli as well as to the more obvious; that is, the average man must react with anger, if personal, national, or international ideals are threatened, as effectively, if not as readily, as when his bodily well-being is attacked by a visible opponent. One great function of a leader is to direct the behavior of his followers in such manner that the correct symbolic processes may become effective in the control of behavior.

The Modification of Fear Behavior in Children.—Mary Cover Jones has published an interesting and valuable series of observations on the modification of fear behavior in children. We shall present a summary of the work done with Peter, two years and ten months old at the beginning of the study. At this time Peter was afraid of a white rat, a rabbit, a fur coat, a feather, cotton wool, etc. Jones' first notes read as follows:

> Peter was put in a crib in a play room and immediately became absorbed in his toys. A white rat was introduced into the crib from behind. (The experimenter was behind a screen). At sight of the rat, Peter screamed and fell flat on his back in a paroxysm of fear. The stimulus was removed, and Peter was taken out of the crib and put into a chair. Barbara was brought to the crib and the white rat introduced as before. She exhibited no fear but picked the rat up in her hand. Peter sat quietly watching Barbara and the rat. A string of beads belonging to Peter had been left in the crib. Whenever the rat touched a part of the string he would say "my beads" in a complaining voice, although he made no

objections when Barbara touched them. Invited to get down from the chair, he shook his head, fear not yet subsided. Twenty-five minutes elapsed before he was ready to play about freely.[2]

Since it was found that Peter was even more afraid of a rabbit than of a rat, the experimental work, after the first observations, was done with the rabbit. Several children who manifested no fear of the rabbit were with Peter at intervals for days, and for a part of each interval the rabbit was present. From time to time Peter was tested alone with the rabbit. The record shows a change from the condition described before to one where Peter allowed the rabbit in the play pen with him, where he affectionately fondled the rabbit and allowed it to nibble his fingers. Much of this conditioning of the behavior was accomplished by feeding Peter in the presence of the rabbit, as well as by the use of social stimuli as described.

Jones describes Peter's condition at the close of the experiment as follows:

> He showed in the last interview . . . . a genuine fondness for the rabbit. What has happened to the fear of the other objects? The fear of the cotton, the fur coat, feathers, was entirely absent at our last interview. He looked at them, handled them, and immediately turned to something which interested him more. The reaction to the rats and the fur rug with the stuffed head was greatly modified and improved.[3]

Jones has also compared various methods for eliminating the fears of certain objects in the case of seventy children from three months to seven years of age. Seven different methods were used: (1) *Disuse.* This was unsatisfactory where the disuse was only for a period of weeks. (2) *Verbal appeal.* This method of overcoming the fears had little or no effect. (3) *Negative adaptation.* Here the subject was left alone with the feared object in order to see if in time the fear would abate. This method tended to aggravate the fear. (4) *Repression.* The child was scolded, teased, or ridiculed

[2] M. C. Jones, "A Laboratory Study of Fear," *Ped. Sem.*, XXXI (1924), 309.

[3] *Ibid.*, p. 314.

by its social equals, but the method was not effective. (5) *Distraction.* The child was given a desired object in the presence of the fear stimulus. The method was effective. (6) *Direct conditioning,* as with Peter, was effective, as was also (7) the method of *social conformity* with the group.

Studies of the foregoing type are suggestive of the mechanisms involved in the method of verbal analysis, psychoanalysis, described in the chapter on "Abnormal Behavior." From the therepeutic standpoint each is essentially a method of re-education which builds upon conditioned reflexes. In order that the best results should be secured the experimenter should know the precise conditions under which the fear, or other instinctive maladjustment, was first set up. With this information he can proceed efficiently to break down the maladjustment.

Inherited Capacities.—Our discussion of the modification of instinct has shown to what a great degree practice within an organism's lifetime may change its inherited forms of response. From this we may pass to the examination of inherited capacities for action whose specific content is supplied by habit. Instinct and habit are the only observable forms of behavior, and differ one from the other in genesis. The inherited capacities which we now discuss are not forms of behavior but are conditions within the organism which we are led to assume in order to account for certain differences of response. A concrete illustration will make this clear. One species of pigeon, the homers, has an unusual ability to return home to the cote from great distances. Official records exist of mature birds who have returned over an air-line distance of 1,000 miles in about 10 days. This concrete behavior is the result of training beginning with returns from short distances and gradually extending to greater and greater distances. The capacity to profit by this training, however, is not acquired. Careful observations by Whitman clearly show that there is no specific unlearned homing behavior in the young pigeon. Homing, among the pigeons, is therefore not an instinct. Rather the homers differ from other varieties in their capacity to profit by training in this specific form of behavior. We

may add to this case the special capacity of some birds for mimicry and of some animal species for gregarious behavior. In none of these three forms of response does heredity determine more than the general nature of the action, training during the individual's lifetime giving the detailed content.

In the human species also we recognize such innate capacities. Some of these have already been noticed, viz., those of general intelligence and the special abilities, musical talent being a possible example of the latter. The precise number of such capacities cannot be stated. We shall probably not greatly err, however, if we add play and gregariousness. In these cases, too, the particular behavior content is determined within the individual's lifetime, while the evidence indicates the presence of an inherited and unlearned capacity to profit by this experience.

The Inheritance of Behavior.—So far in our discussion of unlearned behavior we have assumed that evidence has been, or could be, secured to demonstrate the inheritance of behavior. We must now ask ourselves, "What evidence is there for the inheritance of behavior or of capacities for behavior?" and "What experiments can be performed to secure more evidence?" The students of genetics, who have made extensive studies of the inheritance of eye-color, skin pigmentation, and wing form, offer us nothing on the inheritance of forms of behavior. The method which they follow is the method of cross-breeding. An organism possessing one characteristic is bred with another organsim which lacks this characteristic. The first generation of offspring are then interbred, and the second generation of offspring are likewise inbred. All of this proceeds under uniform environmental conditions. Careful note is taken of the changes in the characteristics under investigation as these occur in the individuals of the various generations. Such experiments are possible only with animals that are fertile and that produce fertile hybrids. So far no experiments have been conducted by this method where the characteristic under investigation is a form of behavior present in one animal and absent in another. The great difficulty is to find organisms that can be bred according to the foregoing plan

and that possess significantly different forms of apparently unlearned behavior. The work of Yerkes and Coburn on the inheritance of degrees of savageness and wildness in rats is a study by this method using as subjects animals of the same species. We may term this method of studying the influence of heredity *the method of experimentally varying heredity while keeping environmental factors constant.*

The second method of gathering data upon the rôle of heredity is *the method which equates the hereditary factors and varies the environment.* Subjects are chosen who have the same essential inheritance, identical twins or members of the same species. If these subjects mature in many different environments, and if they nevertheless manifest great similarities in achievement which cannot be accounted for by hidden common factors in the environments, heredity can be evoked as the explanation of the similarities in achievement. For example, we appeal to heredity to account for nesting behavior in birds of a given species because in spite of widely different environments there is an essential similarity in the nesting behaviors. We may also use heredity to account for the great similarity in behavior test scores made by identical twins, twins developed from the same fertilized ovum, who have been reared in different environments. Such a case has been described by H. J. Muller (1925). The great difficulty in the use of this second method is, to be sure, that the effect of common environmental factors has been excluded.

The third method is to make the environment difficult but constant, for the subjects whose behavior is to be studied, *and to appeal to heredity as an explanation for differences in achievement.* For example: two human subjects are subjected to long and careful musical training from which one emerges a highly skilful performer and the other a very mediocre one; or two pigeons are subjected to long training in homing from which one emerges a splendid homer and the other does not; or two human subjects encounter the problems of social life from which one emerges a genius and the other a moron. Again the difficulty with the method lies in making

reasonably certain that the differences in achievement are not due to uncontrolled differences in environmental factors.

The fourth method utilizes heredity to explain those forms of behavior which show no significant history of learning prior to their appearance. To these forms of behavior belong the unconditioned reflexes, the behavior observed in infants by Watson, and much of the behavior of insects. The most significant behavior of human adults is so modified by environmental factors that it is impossible at the present time to disentangle the unlearned from the learned forms of response.

Method No. 1, if it could be applied, would yield the most dependable results bearing upon the rôle of heredity in determining behavior. To realize that it has not been applied in any very significant way is to realize upon how precarious a basis the present doctrine of instinct rests. And yet, in spite of this, data gathered by the other methods make it reasonable to assume, even in man, the existence of unlearned forms of behavior.

The Origin and Transmission of Instinct.—Theories as to the origin of instinct attempt to reconstruct the process by which in the past history of the race such co-ordinations of reflexes have appeared. When once all or part of the form of behavior has appeared in a given animal, its transmission to subsequent generations is a question of heredity. As such it is a topic for *genetics* and is subject to the laws that govern the transmission of any structure. A connection of neurones, such as underlies fear or anger, is just as much a structure as is the color of the eyes, the existence of the nose, muscles, etc. Each individual inherits receptors and effectors which are essentially like those of his parents. Receptors and effectors are "pure lines," *homozygous characters,* and breed true. If an individual born with one eye (not as the result of accident, but of germinal variation) were crossed with another born with two eyes, the result would undoubtedly be similar to the case of inheritance of eye-color. Here, if one parent is brown-eyed and the other blue-eyed, the offspring of the first generation (F_1) all have a single color, called the dominant color. With respect to color they are hy-

brids. If these individuals interbreed, the next generation (F_2) will be: some pure brown-eyed, i.e., the dominant trait; some mixed; and others pure recessive, i.e., blue-eyed. This form of inheritance is termed Mendelian. The union of the pure dominant or the pure recessive with a similar individual will result in pure progeny with respect to the trait in question. There is every reason to believe that if an animal should be found minus the instinct of fear and could be crossed with an animal in whom the instinct was present, the progeny in the F_2 generation would show the typical Mendelian segregation as just indicated for eye-color. Yerkes and Coburn in fact performed tests of this type upon the inheritance of the instincts of savageness and wildness in rats, securing evidence suggesting the foregoing type of inheritance.

Before an instinct so complex as fear can appear, certain receptors, effectors, and reflex arcs must already have appeared. The appearance of fear adds to this the structural fact of a certain kind of neural co-ordination. We have already seen that no distinction can be clearly drawn between reflexes and instincts. There is no reason, therefore, to separate the question of the origin of one from that of the origin of the other. This, however, is just what the theories of the origin of instinct tend to do. When a receptor or an effector appears in the history of the race, it has a function. If this function (muscular contraction or glandular secretion) is controlled by the nervous system, the function is a reflex (or an instinct). The first appearance of any structure and the first appearance of any inheritable variations in it are both termed chance variations, or "sports." Those which are either useful or at least not particularly harmful survive and become permanent characteristics of the species by the action of natural selection.

Historical Theories of the Origin of Instinct.—Three important theories for the origin of instinct have been proposed. (1) The *lapsed-intelligence theory* of Cope and Wundt holds that originally instinctive acts were performed intelligently; that by repetition they became habitual; and that they were then inherited by the next generation as instincts. This theory is based on the assumption

that acquired characteristics—habits, strength of arm, etc.—can be transmitted by heredity. General biological opinion, however, is against this belief. The theory would further lead us to assume a high grade of intelligence in lower animals, a supposition which is contrary to experimental fact. (2) The *reflex theory* of Spencer holds that the reflexes which make up a given instinct appear one by one, due to chance variations (sports), until the whole instinct is present. This supposition is in essential harmony with the point of view of the last section. The theory has been criticized because it is claimed that the individual reflexes are only valuable as parts of the whole, and by themselves cannot adjust the organism to its environment in such a way as to aid in its survival. Why should a bird pick up straws or weave, it is asked, unless the whole nest-building instinct is present? The answer is clear. What appears first as a chance variation is the fundamental feature of nesting, staying near the eggs or actually hovering over them (Whitman). To this fundamental behavior other elements (digging a depression, collecting straws, etc.) are added by further chance variations. Many of these additional variations may not be necessary for survival (witness the great variations in nest structure), but they may pave the way for, as well as follow after, more complex modes of life. (3) The *organic-selection theory* of Osborn, Baldwin, and Morgan attempts to remedy the supposed deficiencies in the Spencer theory by combining it with certain aspects of the lapsed-intelligence theory. During the period of the imperfect and growing instinct the animal solves its problems partly by intelligence, and accordingly survives. These intelligent variations are not inherited, but must be made anew by each generation. The point is important, but it hardly deserves to be ranked as a separate theory. It calls attention to the fact that habit-formation is a characteristic of all (most) animals and aids in survival, for there is no doubt that without it many or all species would perish. It does not, however, account for the appearance of an instinct in one group and not in another save by the assumption of unequal learning abilities. All

three theories, however, are important for our study because, by laying special emphasis upon different points, they aid us in getting a more comprehensive view of the whole question.

REFERENCES

Bird, C. "The Relative Importance of Maturation and Habit in the Development of an Instinct," *Ped. Sem.*, XXXII (1925), 68–91.

———. "The Effect of Maturation upon the Pecking Instinct of Chicks," *Ped. Sem.*, XXXIII (1926), 212–34.

Breed, F. S. "The Development of Certain Instincts and Habits in Chicks," *Behavior Mon.*, Vol. I (1911), No. 1.

Burks, B. S. "Foster Parent–Foster Child Comparisons as Evidence upon the Nature-Nurture Problem," *Proc. Nat. Acad. Science*, XIII (1927), 846–48.

Carmichael, L. "The Development of Behavior in Vertebrates Experimentally Removed from the Influence of External Stimulation," *Psych. Rev.*, XXXIII (1926), 51–58.

———. "A Further Study of the Development of Behavior in Vertebrates Experimentally Removed from the Influence of External Stimulation," *Psych. Rev.*, XXXIV (1927), 34–47.

Conradi, E. "Song and Call Notes of English Sparrows When Reared by Canaries," *Amer. Jour. Psych.*, XVI (1905), 190–98.

Fulton, J. F. *Muscular Contraction and the Reflex Control of Movement* (Baltimore, 1926).

James, William. *Principles of Psychology* (New York, 1890), Vol. I, chap. iv; Vol. II, chap. xxiv.

Jones, M. C. "The Elimination of Children's Fears," *Jour. Exp. Psych.*, VII (1924), 382–90.

———. "A Laboratory Study of Fear," *Ped. Sem.*, XXXI (1924), 308–15.

Moseley, D. "The Accuracy of the Pecking Response in Chicks," *Jour. Comp. Psych.*, V (1925), 75–97.

Muller, H. J. "Mental Traits and Heredity," *Jour. Heredity*, XVI (1925), 433–48.

Scott, W. E. D. Articles on song birds found in *Science*, XIV, XV, XIX (1901–4).

Shepard, J. F., and Breed, F. S. "Maturation and Use in the Development of an Instinct," *Jour. Animal Behavior*, III (1913), 274.

Sherrington, C. S. *The Integrative Action of the Nervous System* (New York, 1906).

Thorndike, E. L. *The Original Nature of Man* (New York, 1913).

Watson, J. B. *Behavior* (New York, 1914), chaps. iv and v.

———. *Psychology from the Standpoint of a Behaviorist* (Philadelphia, 1919).

Watson, J. B., and Lashley, K. S. "An Historical and Experimental Study of Homing," *Carnegie Institution Publication No. 211* (1915).

Watson, J. B., and Watson, Rosalie R. "Studies in Infant Psychology," *Scientific Monthly* (1921), pp. 493–515.

Whitman, C. O. "Orthogenetic Evolution in Pigeons," Vol. III, "The Behavior of Pigeons," edited by H. A. Carr, *Carnegie Institution Publications No. 257* (1919).

Yerkes, R. M., and Bloomfield, D. "Do Kittens Instinctively Kill Mice?" *Psych. Bull.*, VII (1910), 253.

CHAPTER III

UNLEARNED BEHAVIOR *(Continued)*

Instinct and Emotion.—There exist many words such as fear, anger, anxiety, remorse, sorrow, awe, and ecstasy which are alleged to designate definite forms of response. In certain cases the behavior is overt and readily observable by an experimenter. In these instances the behavior is indistinguishable from the instincts and their modifications with which we have become acquainted in the preceding chapter. Such gross overt forms of behavior set up proprioceptive nervous impulses in the subject which, through social training, result in the verbal responses "I am afraid," "I am angry," etc. These verbal responses constitute the names which convention has set as the labels for the behavior. In most cases the experimenter also is able to name the stimulus-response co-ordination which is present. Often, however, the subject manifests the verbal response "I am angry" when the experimenter cannot observe any overt behavior which might have set off the verbal response. Inasmuch as no response occurs without its stimulus, the experimenter must look to such possibilities as the following for the cause of the verbal response: (1) Some stimulus for anger may be present and arouse the verbal response although the anger behavior itself may not be present. (2) Some parts of the anger behavior may be present at low intensity. Thus there may be a slight clinching of the hands, or a slight tightening of the muscles of the jaws, and these partial forms of behavior may arouse the neural processes which set off the verbal behavior. (3) There may be visceral responses present. These visceral responses, e.g., changes in circulation, respiration, stomach and intestinal activity, and glandular activity, may always accompany overt instinctive activity and hence may be present when the overt activity is non-observable by the experimenter. Moreover, it is quite possible that specific

kinds of visceral behavior may exist unaccompanied by overt behavior of the skeletal effectors. This visceral behavior would be set up by definite stimulating conditions, and it might in its turn arouse characteristic verbal behavior.

The term "emotion" has been applied to behavior of types 2 and 3 as well as to that behavior which we have specifically designated instinctive, or unlearned, behavior. The term "emotion" is also applied to many cases of malco-ordinated behavior where there is likely to be a rapid succession of more or less intense muscular activities. When an animal behaves in such a manner it is said to be excited. This excitement, in man, may or may not be followed by verbal behavior of the type "I am angry." These facts lead us to believe that there is little scientific justification for distinguishing emotional and instinctive behavior. All behavior shows a genetic history of learning or non-learning in the individual's lifetime. That certain responses are made by the skeletal muscles and certain others by the visceral effectors and that the two may be combined in various ways is hardly an adequate justification for making the distinction between instinct and emotion.

Problems in the Study of the Hidden Components of Instinct.—The outstanding problems in the study of the hidden components of instinct are these: (1) Are there specific patterns of visceral behavior which can be correlated with those forms of skeletal behavior called fear, anger, etc.? It is known that blood pressure and heart rate change in moments of anger, fear, or excitement; but the further question which interests us is whether or not a certain change of heart rate and blood pressure is characteristic of these skeletal activities. We shall have occasion to comment upon this problem later. Three other problems which have been under investigation in this particular field should be noted. (2) Even though there may be no distinct patterns of visceral behavior which are characteristic of such behavior as fear and anger, these latter forms of response may nevertheless involve a general and widespread visceral activity which is not present when the fear and anger are absent. (3) Granted the existence of visceral com-

ponents of instinctive behavior, what is their influence upon the unlearned activity of the skeletal muscles? Finally (4) we may note that many investigators have sought to determine whether or not there exist definite facial expressions, i.e., patterns of facial behavior, which are characteristic of definite instinctive activities. Is there, that is, a facial pattern characteristic of anger and one which is characteristic of fear? To be sure, these responses of the facial muscles are not hidden components of instinct; but they are so intimately connected with those components that we are listing the problem in the present context.

Let us first present briefly the evidence for the existence of visceral components in instinctive behavior. We shall then raise the question of the influence of these components upon instinctive behavior. And, after this, we may well consider the evidence for the existence in the facial muscles of pattern responses characteristic of the different instincts.

Visceral Components in Instinctive Behavior.—James and Lange, in their famous theory of emotion, made visceral behavior the fundamental characteristic distinguishing emotion from non-emotion. It has remained, however, for experiment to supply the concrete factual material bearing upon the problem. Changes in visceral responses as a result of the stimuli for instincts and reflexes are of many kinds. These changes occur in blood pressure, in pulse rate and amplitude, in salivary, gastric, and adrenal secretions, in the electrical conditions of the body, and in the muscular activities of the digestive tract. Although experiment has readily demonstrated the circulatory changes just noted, no significant success has attended the effort to demonsrate activities characteristic of the various instincts and classes of stimuli. In particular, many attempts have been made without success to find specific and characteristic circulatory changes accompanying the verbal responses "pleasant" and "unpleasant" when these responses are set up by various stimuli such as odor and visual objects. The same situation is found in the phenomenon known as the galvanic reflex. Here when a small electric current is sent through a circuit which includes

a galvanometer and a part of the subject's body, a certain deflection of the galvanometer is produced. This deflection is changed, as a result of changed electrical conditions in the body, when the subject is stimulated in any one of a variety of ways, as by injury or by words that have aroused anger in the past. The evidence, however, does not indicate the occurrence of deflections which are characteristic of the various stimulating conditions.

The most significant work which has been done on the visceral components of instincts concerns changes in glandular secretions and in the activities of the digestive tract. Since 1909, W. B. Cannon, of the Harvard Physiological Laboratory, and his students have published a series of papers chiefly concerned with the effects of injurious stimuli and of fear and rage upon the activities of the digestive tract and with the presence of secreted adrenin and its effect upon the body during fear and rage. Cannon has shown conclusively that the normal contractions of the stomach and intestines are quickly inhibited in fear and rage, and following injurious stimulation. Not only is this condition true, but the salivary and gastric secretions are also checked.[1] This last point has been established by exposing a portion of the wall of the stomach through a permanent fistula and noting the changes in gastric secretion here incident to the foregoing situations. The changes in salivary flow (the dryness of the mouth in fear, e.g.) are matters of common knowledge. Inhibition of peristalsis in the intestines was demonstrated by observing the animal prior to, and again during, the excitement, with the Röntgen rays. Prior to the excitement peristalsis would be progressing normally, only to stop when the fear, or rage appeared, or when the injurious stimuli were applied.

The most interesting part of this work by Cannon, however, lies in the studies of the adrenal glands. These glands lie just anterior to the kidneys and are supplied by nerve fibers of the sympathetic system. They are ductless, pouring their secretion, adrenin, directly into the blood stream. Most of the data have been secured

[1] This was shown by a long series of observers, notably Pavlov, prior to Cannon.

from cats by the use of careful surgical and physiological methods which space will not permit us to describe. Accordingly the following brief statements must represent for us the present status of our knowledge. The stimulation of an animal by injury or by the excitement in fear and rage is accompanied by the stimulation of the adrenal glands through the fibers of the sympathetic nervous system. The adrenin consequently thrown into the blood results in: (*a*) driving the blood from the viscera to the skeletal muscles, where it increases muscular efficiency; (*b*) increased conversion of glycogen from the liver into blood sugar; (*c*) decrease in muscular fatigue; and (*d*) decrease in the time required for the coagulation of the blood. These changes are all in the direction of increased body efficiency. The increased blood sugar puts more fuel at the disposal of the skeletal muscles, whence it is driven through the action of the adrenin. In the case of wounds, which usually result from injury, fear, and rage, the blood clots rapidly. No essential variation in these facts was found for the three excitements studied. Unfortunately we have no experiments available for non-combative emotions, and consequently we are unable to say whether the foregoing physiological changes do or do not occur in such cases.

These studies open up in a vital manner the field of visceral disturbances, where James felt sure the fundamental "cores" of particular emotions arose. Cannon, however, wrongly interprets his facts as antagonistic to the James-Lange theory. On the contrary, they support the theory strongly by indicating a very delicate and widespread bodily disturbance during emotional seizures. Although fear and rage cannot be differentiated on the basis of the organic disturbances produced by adrenin, further delicate investigations might discover a differentiating factor even here. So far there is but little evidence for specific patterns of visceral response characteristic of the various instincts.

The Influence of Total Visceral Disturbance upon Overt Instinctive Behavior.—We have already seen in Cannon's experiments that an increased capacity for muscular work results from the activity of the adrenal glands. This increased work is made

possible by the decrease in fatigue, by the increase in blood sugar, and by the increased flow of blood to the skeletal muscles. The secretion of other glands, such as the thyroid and the sex glands, are also important in the regulation of skeletal behavior. Hyper-thyroidism is accompanied by increased excitability of the subject, while hypo-thyroidism is marked by sluggishness and a generally low level of behavior capacities. The rôle of the sex glands is markedly shown by a comparison of normal behavior with that of castrated subjects. Our present interest concerns the influence of the total visceral activity upon overt instinctive behavior. If the sensory impulses from the viscera get no access to the skeletal muscles, will these latter respond in the usual manner to stimuli which normally arouse overt instinctive behavior? For example, certain stimuli applied to a dog will arouse fear or anger responses. Would the same responses appear if the nervous impulses from the viscera could not reach the central nervous system and so modify the motor impulses which pass to the subject's muscles?

C. S. Sherrington, the English physiologist, has sought to secure crucial evidence of the foregoing type on the James-Lange theory by experiments on dogs. The animals used had their spinal cords transected just below the medulla, thus having most of the sensory impulses from the body cut off as far forward as the shoulders. Fear, anger, and disgust were still clearly shown in the head and fore-limb segments of the animals. Other experiments were made where the Xth cranial nerves (the vagi) were sectioned, whereby the stomach, lungs, and heart were removed from having any possible effects upon behavior; and yet the fore-dog behaved as before. Still other tests were made upon puppies nine weeks old, in order to verify a possible objection to the other tests that the emotional behavior secured was due to the effects of past training. In these cases, too, clear traces of emotions were present. As a result of his work, Sherrington holds that organic processes cannot be the essential elements of emotional behavior.

One very significant objection is valid against these experiments, so far as they may be held to invalidate the James-Lange

theory. The only fact that Sherrington has is that the movements in the anterior part of the animal were not changed in character or intensity by the operation. There is no clear reason why the spinal animals should *not* have gone through certain instinctive reactions in their anterior segments. The nerves from the eyes, ears, nose, mouth, diaphragm, and skin were still intact and sent impulses to the brain. The reflex arcs belonging to the fore-animal were still intact. The fact that the motor impulses could not reach the hind-animal and there result in muscular activity and in sensory impulses is no reason for inactivity in the fore-animal. It is doubtful if crucial evidence on the validity of the James-Lange theory can be secured by a method of this type.

James emphasized, with reference to our present problem, the importance of clinical cases where the subjects are totally anaesthetic. James wrote as follows:

> A positive proof of the theory would, on the other hand, be given if we could find a subject absolutely anaesthetic inside and out, but not paralytic, so that emotion-inspiring objects might evoke the usual bodily expressions from him, but who, on being consulted, should say that no subjective emotional affection was felt. Such a man would be like one who, because he eats, appears to bystanders to be hungry, but who afterwards confesses that he had no appetite at all. Cases like this are extremely hard to find. Medical literature contains reports, so far as I know, of but three. In the famous one of Remigius Leins no mention is made by the reporters of his emotional condition. In Dr. G. Winter's case the patient is said to be inert and phlegmatic, but no particular attention, as I learn from Dr. W., was paid to his psychic condition. In the extraordinary case reported by Professor Strumpell (to which I must refer later in another connection) we read that the patient, a shoemaker's apprentice of fifteen, entirely anaesthetic, inside and out, with the exception of one eye and one ear, had shown *shame* on the occasion of soiling his bed, and *grief,* when a formerly favorite dish was set before him, at the thought that he could no longer taste its flavor. Dr. Strumpell is also kind enough to inform me that he manifested *surprise, fear,* and *anger* on certain occasions.[2]

[2] W. James, *Principles of Psychology* (1890), II, 455–56.

The material which we have cited in the present section is quite inadequate to answer fully the question with which we began. So far as the evidence goes, however, it supports the conclusion that the pattern reactions of instinct, as these appear in the behavior of the skeletal muscles, are relatively independent of the visceral disturbances which ordinarily accompany them.

Facial Behavior in Instincts.—Does the human subject manifest facial behavior which is peculiar to each of the various instincts? Changes in facial behavior are unquestionably important factors in social behavior. Facial expression in subject No. 1 may call forth, in subject No. 2, verbal responses which are the conventional names for the facial pattern, or it may set up either verbal or non-verbal responses of other types, as when an angry face is responded to with anger or with mirth. Experimental studies of facial behavior have paid but passing attention to this latter problem. The two problems which have received the greatest emphasis are: (1) The accuracy with which still photographs of facial behavior can be identified with reference either (*a*) to the emotion which the sitter sought to enact or (*b*) to the emotion which arose in the situation that lead to the facial expression. And (2) moving or still pictures have been made of subjects who were reacting to experimentally controlled situations. Later the photographs have been analyzed in an effort (*a*) to determine whether or not any facial pattern is characteristically evoked by any given situation and (*b*) to determine which part of the face dominates the facial pattern.

Let us consider the last problem first. Dunlap (1926) has secured still photographs of adults stimulated in the laboratory by the following among other situations: (1) after adjustment to the conditions of the photographic room (a natural facial behavior), (2) jokes casually introduced (amusement), (3) anecdotes which aroused laughter (mirth), (4) the unexpected firing of a pistol (startle), (5) forcibly bending the finger back (pain), (6) olfactory stimulation with decayed meat (disgust), (7) death of members of family suggested under hypnosis (grief), and (8) muscular work after which the subject rested (relaxation). Dunlap combined

the upper and lower portions of the facial photographs in an effort to learn whether the eyes or the mouth region determines the inter-

FIG. 43.—Combinations of mirth and pain (after Dunlap). The upper photographs are the originals.

pretation placed by an observer upon the facial pattern. Figures 43, 44, and 45 show combinations from the photographs of mirth

and pain, pain and startle, and grief and relaxation. Fifty psychology students studied the entire series in order to determine which of

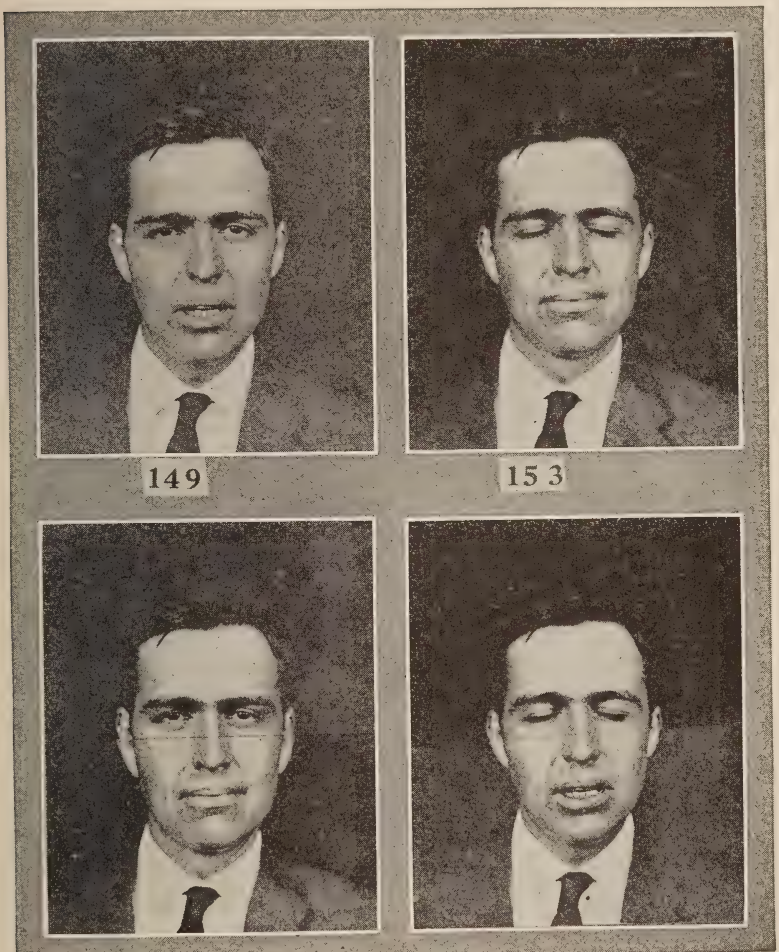


FIG. 44.—Combinations of pain and startle (after Dunlap)

the two originals (shown at the tops of the figures) each composite most nearly resembled. The results indicate that the pleased char-

acteristic of the face is determined almost entirely by the mouth. This dominance of the mouth was also found with most of the com-

FIG. 45.—Combinations of grief and relaxation (after Dunlap)

binations, although it was not so nearly true with combinations of grief and relaxation and of mirth and pain.

Landis (1924–25) likewise has photographed adult subjects in the laboratory under conditions (more severe and varied than those

of Dunlap) arranged to call forth marked instinctive reactions These photographs have been compared with others made of subjects who have been asked to manifest the facial responses which they regarded as the responses characteristic of various emotions. The former photographs have also been analyzed by the experimenter (rather than by a group of subjects) with reference to the existence of facial patterns of response. Landis found that none of the stimulating situations which he employed called forth facial behavior which was characteristic of that situation. This was true although the situations were well calculated to arouse anger, fear, disgust, and other marked forms of behavior. Where subjects attempt to behave as they would behave if angry or in awe, conventional facial behavior alone was manifested. This behavior does not correspond with that actually present under instinctive stimulation. It is rather a conventional artifact of the same character as sign language. Landis makes the following significant statement concerning the identification of individual instincts, a topic which we shall consider in the following section: "As the experimental work stands at present it seems more probable that when an organism is in a situation which results in a disturbed or wrought up condition, then the situation plus the reaction gives us a name or word which characterizes the whole. . . . ."[3]

No study of facial behavior has brought forward results which will indicate how much of the behavior is unlearned and how much is learned. It is probable that such results, if available, would show that facial behavior in the adult is almost entirely learned; indeed, not only learned, but conventional. Individuals are reared in a social situation which through art and through more direct social pressure has long placed a premium upon certain types of facial behavior. It is no more surprising that the individual should fit into the common mold in this behavior than in the case of the more obvious customs. There is a certain facial pattern which artists have used to portray anger, another for horror, and yet another for reli-

[3] C. Landis, "Studies in Emotional Reactions. II. General Behavior and Facial Expression," *Jour. Comp. Psych,* IV (1924), p. 496.

gious awe. These patterns find individual expression in behavior as truly as moral tenets get an expression in behavior.

The Rôle of the Stimulus in the Identification of Instincts.—In the experiments which we have just discussed the identification of specific instincts has usually been attempted in terms of the response alone. Such an attack upon the problem is valuable, but it only partly envisages the situation. Behavior is set up by stimuli. Consequently a knowledge of the stimulus may well be as important for the identification of a form of behavior as a description of the behavior. Many experiments suggest this conclusion, and a study by Sherman (1927) clearly indicates it. Sherman had observers attempt to identify the behavior aroused in infants by four stimulating conditions: delay in feeding, bodily restraint, pin-pricks, and dropping from a height of some two feet. In certain cases the observers saw (in moving pictures) the stimuli as well as the behavior which was set up in the infants. In other cases the pictures showed only the infants' responses. The observers were asked in each case to identify the behavior by naming it. The degree of success in this naming was much greater when the observer saw the stimulus than when he saw only the response. Even in this latter case the observers were not all agreed upon the name to be applied to the behavior, whether it should be called, e.g., hunger or anger, or anger or fear.

The accurate differentiation of forms of behavior involving the organism as a whole is a difficult matter. This is not the case when the responses of individual organs are compared. It is easy to differentiate between arm and leg movements, or between breathing and typewriting, on the basis of the various effectors involved. It is not so easy to distinguish between fear, anger, hunting, and nest-building. These are total activities of the organism, activities which are very complex in longitudinal section as well as in cross-section. We are aided in the identification of these complex responses partly by the observation of the relevant stimuli, partly by the character of the behavior, and partly by the results of the behavior, e.g., by the capture of prey or by the gradual growth of the pile of straws which make the nest. We shall continue the discussion of this prob-

lem of the identification of behavior later in the chapter on "The Correlation of Stimulus and Response."

The Neural Basis of Instincts and Emotions.—Instincts and emotions are forms of behavior controlled by co-ordinations of synapses in the nervous system. These co-ordinations arise partly as a result of intrinsic growth factors rather than merely as a result of training in the individual's lifetime. Too little progress has been made in the physiology of the nervous system to enable us to specify in many cases whether one part of the nervous system is chiefly concerned with one instinctive act and another part with another instinctive response. In the chapter on the nervous system we pointed out that the cerebellum is chiefly concerned in maintaining muscle tonus and in regulating equilibratory behavior. The medulla is particularly concerned in the control of breathing and circulation. Various sympathetic ganglia control the unlearned activity of visceral effectors. With reference to such forms of behavior as anger and fear, we can say very little except that the neural centers concerned must be very numerous and very complexly interrelated and that many cerebral centers must be involved. The following observations by Henry Head and Gordon Holmes (1911) would indicate that many of the neural centers for instinctive behavior are subcortical, and that the cortical influence upon these centers is largely one of inhibition and control. These investigators studied the behavior of patients with lesions in one half of the thalamus (unilateral thalamic lesions). When these lesions were in the anterior portion and consequently interrupted impulses from the thalamus to the cortex, and vice versa, the following facts were noted relative to behavior on the side of the body affected: Irrespective of whether or not the body area to be studied was more or less sensitive than normal, pin-prick, painful pressure, extremes of heat and cold, visceral sensitivity, scraping, roughness, and vibration called forth on this area an excessive response. The same was true for such stimuli as music. One patient, e.g., could not go to a concert because the affected part of her body became too excited! These results of Head and Holmes suggest very strongly that the essential brain

center concerned in emotion is the thalamus, and that the influence of the cortex upon it is essentially one of control and inhibition.

Mood and Temperament.—Moods and temperaments are not instincts and emotions. They represent more or less permanent predispositions, or tendencies, to behavior of a certain type. An individual may be in a gloomy or a joyous mood, an angry or a fearful mood. These moods are of relatively brief duration and indicate that the person is particularly likely to manifest anger or fear upon the presentation of stimuli which would ordinarily be too faint or irrelevant to arouse the behavior. By "predisposition" we mean that the synaptic connections in the individual are so affected as to make probable the appearance of these types of behavior. The predisposition may be set up by indigestion, poor sleep, good or bad news, etc. A person whose mood is particularly inconstant is "one of moods."

By temperament we refer to behavior predispositions that are possibly innate and that probably vary but little during large periods of the individual's life. Historical usage has recognized four chief classes: the *sanguine,* the *ardent (choleric),* the *nervous,* and the *phlegmatic.* The sanguine are characterized as people of optimistic outlook, of ready but feeble emotional response. The ardent and the nervous are much alike, being individuals who are excitable and whose emotions succeed each other rapidly and with more than medium intensity. They are the reformers and prophets. With the phlegmatic, on the other hand, emotions change slowly and are aroused with difficulty. The melancholic is also a temperament often recognized. Here depressive behavior tends to prevail, appearing with marked intensity and changing but slowly.

Instinct and Intelligence.—From our extended account of instinct one must not conclude that it is a separate and distinct type of behavior. We have already seen its intimate relationship to reflex actions and are now to consider it in connection with intelligence. Popular opinion assigns a preponderance of instinct to the animals and retains intelligence for man. If we use the term intelligence as synonymous with "thinking," that view is undoubtedly

correct. In the better sense of the term, however, we mean by intelligence learned and variable behavior. To the extent that responses are determined by heredity, they are instincts; to the extent that they are modifiable within the animal's individual experience, they are intelligence. Instinct and intelligence, then, go hand in hand through the animal series.

Instinct and Habit.—Habits as well as reflexes and instincts are modes of response. *Habits are acquired co-ordinations of reflexes.* They differ from both reflexes and instincts in their acquired character, and in addition they are more complex than the former. An illustration will serve to make this clearer. Writing is a mode of muscular response which depends upon the proper adjustment and co-ordination of the reflexes of the hand and arm. Individuals do not develop this capacity for response without training, although the movements of the specific muscles appear early in childhood. Therefore writing cannot be an instinct, but is clearly a habit. Its elemental parts, as reflexes, are inherited; but the harmonious relationship of these, which is the essential characteristic of the response, is acquired. Contrast the situation with that of an instinct. Instincts, too, are composed of elemental reflexes, and inasmuch as they are modified by experience include phases that may be termed habits (intelligence). Yet however much fear or anger may be modified, the essential dominating characteristic of the mode of adjustment is still hereditary, and we term the response an instinct. Some instincts are more impulsive, more compelling, more irresistible, than any non-instincts ever are, i.e., they have the "right of way" over other forms of behavior to a very large extent. No acquired response could approximate the impulsive character of a panicky fear or a blind rage.

The important general problems in the study of habit formation grow out of the fact, first, that habit is a response to stimulation, and second, that it is affected by other habits and by instincts. In the first instance it is necessary to investigate the following questions: (1) What sensory factors control the behavior? This type of study we illustrated in the account of maze learning. (2) What

specific responses make up the behavior? (3) What is the process of habit-formation, and what are the conditions influencing it? And (4), what is the rôle of habit in the individual and social life-histories of the individual? In the second instance the problems of chief concern are: (1) What is the relation of habit to instinct? (2) Into what relationships of interference, transfer, and combination may habits enter? And here as elsewhere the study of conditioning factors is important.

Instinct and Habit, Descriptive Terms.—The terms "habit" and "instinct" are chosen to designate the two fundamental divisions of observable behavior, divisions made upon the basis of acquired versus inherited origin. The terms are descriptive and not explanatory. It is undesirable, therefore, to say that we behave in this way *by* instinct and in that way *by* habit. The behavior *is* the instinct or the habit. If an explanation of the behavior is desired, one must go outside of the response itself to stimuli and nervous conditions, just as when one wishes to explain the appearance of light from an electric bulb he must do so in terms of the switch and the other electric connections. The final summary of habit formation must come in chapter vi. At that time it will be well, therefore, to reconstruct as well as one may our present account of habit as an acquired co-ordination of reflex responses.

REFERENCES

Angell, J. R. "A Reconsideration of James's Theory of Emotion in the Light of Recent Criticisms," *Psych. Rev.*, XXIII (1916), 251–61.

Cannon, W. B. *Bodily Changes in Pain, Fear, Rage, and Hunger* (New York, 1915).

Darwin, Charles. *The Expression of Emotions in Man and Animals* (New York, 1873).

Dunlap, K. "The Rôle of Eye-muscles and Mouth-muscles in the Expression of Emotions," *Genetic Psych. Mon.*, II (1927), No. 3.

Head, H., and Holmes, G. "Sensory Disturbances from Cerebral Lesions," *Brain*, XXXIV (1911), 109 ff.

Herrick, C. J. *Introduction to Neurology* (4th ed., Philadelphia, 1927).

James, W. "What Is an Emotion?" *Mind,* IX (1884), 189–205.

———. *Principles of Psychology* (New York, 1890), Vol. II, chap. xxv.

———. "The Physical Basis of Emotion," *Psych. Rev.,* II (1894), 516–29.

Ladd, G. T., and Woodworth, R. S. *Elements of Physiological Psychology* (New York, 1911), Part II, chap. vii.

Landis, C. "Studies in Emotional Reactions. I. A Preliminary Study of Facial Expression," *Jour. Exp. Psych.,* VII (1924), 325–41.

———. "Studies in Emotional Reactions. II. General Behavior and Facial Expression," *Jour. Comp. Psych.,* IV (1924), 447–501.

Lange, C., and James, W. *The Emotions,* "Psych. Classics" (Baltimore, 1922).

Ribot, Th. *The Psychology of the Emotions* (2d ed., London, 1911).

Sherman, M. "The Differentiation of Emotional Responses in Infants," *Jour. Comp. Psych.,* VII (1927), 265–84.

Sherrington, C. S. "Experiments on the Value of Vascular and Visceral Factors for the Genesis of Emotion," *Proc. Royal Soc. London,* LXVI (1900), 390 ff.

Watson, J. B., and Rayner, R. "Conditioned Emotional Reactions," *Jour. Exp. Psych.,* III (1920), 1–14.

Watson, J. B. *Behaviorism* (New York, 1924).

CHAPTER IV

RECEPTOR PROCESSES

Introduction.—The problem of receptor processes is one of the most important problems for the understanding of behavior inasmuch as the great majority of responses made by the organism are a result of the nervous impulses set up in the receptors by the action of stimuli. If we are to understand behavior we must first understand the adaptation which exists between the receptors and the stimuli which affect them. In the exposition of receptor activities we shall be interested in all phases of this adaptation. We shall study the ways in which stimuli may affect the receptor and the limits of receptor sensitivity. Practically all of the evidence that can be secured concerning these questions is in terms of the behavior of muscles and glands. Only occasionally is it possible to examine the receptor directly in order to determine whether or not it has been affected by stimulation. Inasmuch as the functions of the receptors depend upon their structures, we shall also need to learn all that we can of their gross and microscopic anatomy.

General Methods of Studying Human Receptor Processes.—We have just said that receptor processes are studied by means of the behavior aroused by those processes, and in the chapter dealing with animal behavior we have seen concrete examples of the methods used in determining receptor sensitivity in infrahuman animals. Practically all studies of human receptor processes are made by the verbal-response method, using either vocal-verbal or manual-verbal responses. The conditioned reflex and the non-verbal methods described in connection with infrahuman studies have not been used on a significant scale with man.

It is always to be remembered that the verbal response does not *describe* the stimulus any more than does the non-verbal response. A leg movement, a twitch of the finger, or a contraction of the mus-

cles of the iris are *as descriptive* of the stimulus as a word. Verbal responses have been highly developed in man, however, so that the usual subject has a more complete *repertoire* of such responses than of non-verbal responses to make to stimuli.

The general procedure for the use of the verbal-response method in the study of receptor processes is as follows:

1. A subject is chosen who has already learned to make a given verbal response, e.g., the vocal-verbal response of saying "red" when a certain portion of his retina is stimulated by light of a certain wave-length. In such a subject the same response, however, will have been connected by training with many other stimuli, like "What are the color names?" and also with kinaesthetic sensory impulses. This latter case is illustrated when the response "red" follows the response "green" (when the subject says, "Yellow, blue, green, red").

2. Because of the large number of stimuli that will arouse any given verbal response, e.g., the response "red," and because of the large number of verbal and non-verbal responses that any one stimulus may arouse in the subject as a result of his varied (and unknown) past training, it is necessary to give him certain *instructions*. These instructions may be: "When you first see red, say '*red*' or '*now*.'" These instructions, in the form of auditory or visual stimuli, serve two purposes. They facilitate the response which it is desired to arouse, and they inhibit other possible responses to the stimulus which is being used.

3. A stimulus is applied to the receptor under the conditions of the experiment, and a record is made of whether or not the subject gives the indicated response. If we are investigating the length of time necessary for a *red* stimulus to act upon the receptor in order to arouse the verbal response "red" rather than "light," we first stimulate the subject auditorily by saying, "When a red light appears, say *red*." We then turn on the light and measure the time from the application of the stimulus to the appearance of the response.

We may illustrate the mechanism of the verbal-response meth-

od by the diagram of Figure 46. By virtue of previous training, nervous impulses aroused by light of a given wave-length acting upon the receptor, *Rv*, may go to the effector, E_1, with the result that the effector contracts and so says "red." These impulses may go to *E*, with the result that the subject stops walking, or says "color," or does any one of a number of things for which he has

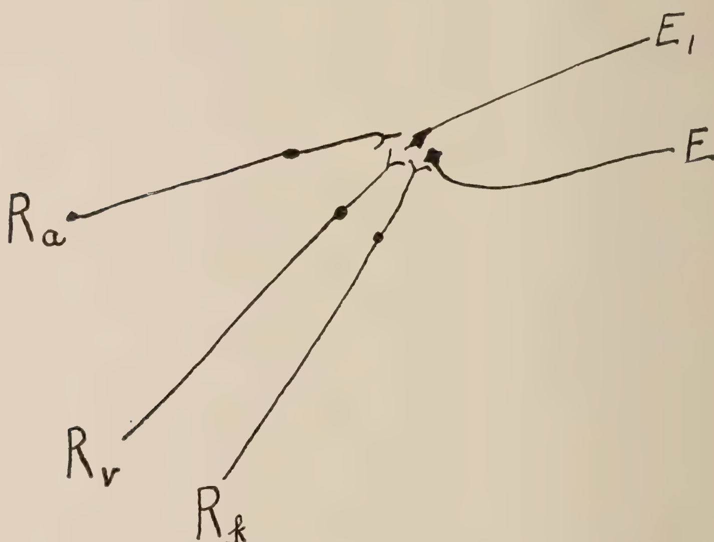


FIG. 46.—The mechanism of the verbal-response method

been trained. Effector E_1 may also contract to make the sound "red" as a result of auditory stimuli at *Ra*, the ear, or of pressure upon the kinaesthetic receptor *Rk*. In order to control this situation—and the real situation is much more complex than we have indicated—the subject is seated in a laboratory so that the walking response, and many other possible responses to the red stimulus which are incompatible with being seated in a laboratory for experimental purposes, will not be aroused. We then stimulate *Ra* with the words "When you first see red, say 'red' or 'now.' " The nerv-

ous impulses from this stimulus serve to facilitate the activity across the pathway $Rv–E_1$ and to inhibit activities in other reflex arcs which would interfere with $Rv–E_1$.

The reliability of any method in which we use behavior as an evidence of the effect of stimuli depends upon the accuracy with which the behavior can be related to the stimuli. In spite of the many obvious sources of error in the verbal-response method just described, highly accurate results can be obtained *when it is possible to know when the stimulus is applied and what the stimulus is.* This knowledge is almost impossible for those stimuli which arise within the body, i.e., subcutaneously. Here we can learn but little, at present, concerning what stimuli are active and when they are active. As a consequence we have little reliable information concerning the functions of subcutaneous receptors.

The Classification of Receptors.—There are many different classifications of receptors, all of which are suggestive but no one of which is thoroughly satisfactory. Hearing, kinaesthesis, touch, and the static receptors are often referred to as the mechanical ones, inasmuch as they are aroused by mechanical stimuli. Taste, smell, and vision are then the chemical receptors. Pain will fall under either grouping because the pain receptor can be activated both by mechanical and by chemical stimuli. The temperature and visceral receptors cannot be definitely placed in this scheme. Opposed to this method, common sense groups receptors upon the basis of the apparent organ involved: vision, hearing, touch, taste, and smell. The grouping in this form is inadequate for at least two reasons: (1) it is superficial and does not list all of the receptors; and (2) it passes over the fact of fundamental biological value that certain receptors are stimulated by objects that act from a distance, certain others by objects that act upon contact with the body, and by still others that are effective within the body. Science further points out that there are at least four different kinds of receptors in the skin and adjacent tissue. It advances evidence indicating that the taste receptor is probably composed of four different kinds of receptors, conditioning the responses to sweet, salt, sour, and bitter stimuli,

and that vision and hearing themselves may each include two receptors.

The most satisfactory classification (a scientific adaptation of that of common sense) is based upon the differences between receptors and is proposed by Sherrington. In its essentials it is as follows:

1. *Proprio-ceptors,* receptors lying between the external surface of the body and the internal surface (alimentary tract) and chiefly located in the muscles, joints, tendons, and semicircular canals of the ear (static receptor). The stimuli involved are due to the organism's own activity, muscular and glandular.

2. *Intero-ceptors,* receptors lying along the alimentary tract and stimulated by that portion of the environment there included. Taste, thirst, pain, and temperature receptors in the stomach belong here.

3. *Extero-ceptors,* receptors in the external surface of the body, stimulated by changes in the outer environment. Included here are vision, hearing, smell, and the cutaneous receptors. This class is divisible into *distance receptors* and *contact receptors.* Contact receptors are the only extero-ceptors that cannot be distance receptors. Vision, hearing, and smell receptors will each respond to contact-stimulation of their gross structure (blows on the head and odorous substances in the nose). Pain and temperature receptors will respond either to stimuli acting from a distance or to those acting in contact with them.

As a supplement to this classification, it is of much biological importance to note that the distance receptors have different functions as a result of the kinds of stimuli which affect them. One of these stimuli, light, is transmitted only in a straight line. The eye is therefore the receptor best suited to spatial discrimination, i.e., to control behavior with reference to the size, form, and distance of the stimulus. The other stimuli of heat, odor, and air-vibrations (for the ear) will bend around intervening objects. They are, therefore, not suited to determine accurate behavior with respect to the space characteristics of an object. They find their great value in

arousing behavior, although the objects are not in an unobstructed straight line from the receptor. In this way food, mates, and enemies are reacted to, although they may be screened from view. It is to be borne in mind that receptors are structures in the body which have been developed and specialized with a view to making it possible for the animal to react to certain forces in its environment. They are the places on the organism that are particularly sensitive to light, sound, heat, and other stimuli. Many forces, such as X-rays and ultra-violet light, do not in nature stimulate the human organism because there are no receptors adjusted to them. It is an open and possibly an unanswerable question whether man could adjust himself to his environment better if he possessed receptors for those forces which are not now effective.

Taste.—Taste receptors are ciliated cells contained in the taste buds that are found in the walls of the crevices of the tongue (Fig. 47). In adult human subjects these taste buds are found only on the upper surface of the tongue (the middle excepted), in the soft palate, and on the posterior side of the epiglottis, while in children they are also found in the cheeks and on the middle of the tongue. In fish, taste buds are often found scattered over the external surface of the body and on the barbules. Taste receptors in man are supplied by the VIIth and the IXth cranial nerves. The cortical center to which the nervous impulses from the taste-receptors go is not definitely known, but it is probably near the hippocampus.

The stimuli for taste are certain chemicals in solution. The solution enters the crevices of the tongue and so gets access to the hair cells of the taste bud. It is also probable that certain solutions in the blood affect either the receptors for taste or the neural centers. This is evidenced by the fact that, when the sugar content of the blood is high, the subject may respond in part as if his receptor were stimulated with a sugar solution. Again, during jaundice the subject may respond in part as if quinine solutions stimulated his taste receptors, and it is known that the bile content of the blood is high in this disease. No significant success has attended the effort to relate the various taste stimuli to the chemical groups.

Microscopically the ciliated receptors in the taste buds are all alike. We may demonstrate certain functional differences, however, which lead us to believe that there are four different kinds of receptors. (1) More diluted solutions of sugar and salt will arouse responses when applied to the tip of the tongue than when applied elsewhere. Responses to sour solutions are most easily aroused from the sides of the tongue. Responses to bitter solutions, e.g., quinine solutions, are most easily aroused from the receptors at the back of

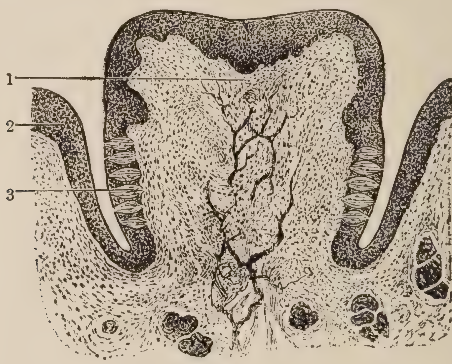


FIG. 47.—A section through a papilla of the human tongue. 1 is the papilla, 3 is the taste bud (after Cunningham).

the tongue. (2) Small areas of the tongue can be found where there is no differentiation between the four standard taste solutions of salt, sour, sweet, and bitter. Other areas may differentiate between two, three, or all four of the solutions through the arousal of different verbal responses. (3) Certain substances arouse one response when applied to one part of the tongue and another response when applied to another part. Thus saccharine solutions applied to the tip of the tongue arouse the same response that sugar solutions do, but when applied to the back of the tongue the response is that usually aroused by bitter solutions. (4) Certain drugs act selectively upon the receptors. A 10 per cent solution of cocaine, if applied to the surface of the tongue, will destroy its sensitivity, i.e., render

it anaesthetic, first to bitter, and then, as the application continues, to sweet, salt, and sour stimuli. This destruction of sensitivity is proved by the failure to arouse verbal responses to the stimuli in question. Gymnemic acid temporarily destroys the capacity for making verbal responses to sweet and bitter solutions, but it has no effect upon the stimulating value of sour and salt solutions. These incapacities of the receptor for taste are termed *ageusia.* To the extent that these four groups of data indicate that sweet, salt, sour, and bitter solutions may stimulate the receptors as independent variables, to that extent they indicate the existence of four types of receptors rather than of one.

Several other phenomena of taste sensitivity deserve mention. All responses made in the course of daily life to stimuli acting upon the mouth cavity are determined by the activities of a variety of receptors. Some of these receptors are excited by changes of temperature, some by pressure, some by stimuli which call forth the same response as does a light pin-prick, and some by the stimuli which act upon the taste receptors. Only experimental conditions can isolate the various forms of sensitivity. Many solutions in the mouth also give off gases which affect the receptors in the nasal cavity, so that the resulting behavior is determined by nasal receptors as well as by those of the mouth.

The great variety of verbal responses made to stimuli in the mouth cavity is due to the great variety of ways in which the various receptor processes may be combined. It is further interesting that after certain stimuli, e.g., sugar solutions, have been acting upon the taste receptors, the receptors are more sensitive than normal to certain other stimuli, such as acid and salt solutions. The most striking instance of this occurs when the two substances are applied simultaneously to opposite sides of the tongue. If a salt solution, too weak to arouse the verbal response "salt," is placed upon one side of the tongue, and a mediumly strong sugar solution, which readily arouses the response "sweet," is placed upon the opposite half of the tongue, it will be found that the salt stimulus can now arouse the verbal response "salt," when facilitated in a highly

trained subject by the proper instruction stimulus. It is worth noting in this connection that the two halves of the tongue are supplied with nerves from opposite sides of the brain; consequently the two chemical processes cannot interact in the tongue.

Smell.—It has already been pointed out that the receptors in the nasal cavity and those in the mouth cavity are so closely related that it is often difficult to determine which of the two groups is controlling behavior. The nasal cavity is well supplied with receptors which are stimulated by temperature changes, by contact, and by injury. These receptors are supplied with fibers from the Vth cranial nerve. Smell proper concerns only those receptor processes which send impulses over the Ist cranial nerve. The smell receptors are ciliated cells located in a portion of the mucous membrane of the nose. They differ from the taste cells in that they are cell-bodies of neurones, whereas the taste cells are separate non-nervous cells in which the sensory nerves terminate. It is possible that this anatomical difference is largely responsible for the fact that the olfactory receptor is much more sensitive than that of taste. Figure 48 shows the area in the nose supplied by the olfactory, or Ist cranial, nerve.

Parker and Stabler have made tests upon the relative sensitiveness of the taste and smell receptors, using ethyl alcohol as the stimulus for each. The results indicated that the smell receptor is approximately 24,000 times more sensitive than that of taste. The former is essentially a distance receptor for stimuli that bend. Although the stimulus for smell is usually said to be odorous particles in gaseous form, Parker and others have shown that in fish the receptors connected with the Ist cranial nerve can control behavior when stimulated by substances in solution, and it is known that the olfactory membrane in man is constantly bathed in mucous. It is therefore quite probable that the stimulus for both the olfactory and the gustatory receptors is a substance in solution. The two receptors differ functionally primarily in their relative degrees of sensitivity. Opinion is divided upon the relative priority of the two in animal development.

So far experiment has presented less evidence that the smell receptors are of various kinds than we found to be the case in taste. In neither instance does the microscope reveal different classes of ciliated cells. Those of smell are uniform, and so are those of taste. Data relevant to this question and to the broader question of the peculiarities of olfactory sensitivity can be gleaned from cases of the partial loss of sensitivity to odors (*anosmia*) and from studies of olfactory fatigue. In these instances, due to accident or to laboratory conditions, certain odors fail to stimulate the receiving organs. Fatiguing the olfactory membrane for iodine, for example, will, according to Arnsohn, destroy the capacity to respond to alcohol, heliotropine, and other odors; it will weaken the effectiveness of hyacinth, oil of mace, and oil of citron; and it will either increase the receptor's sensitivity or leave it unaffected for ether and other odor stimuli. It is by tests of this type that it may be possible to determine the stimulus components of complex odors. This is true because if the receptor is exhausted for stimulus X, and the complex stimulus XY is then presented, X cannot be effective and the re-

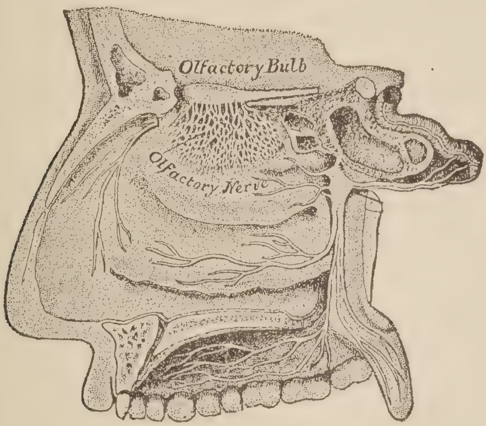


Fig. 48.—The distribution of the olfactory nerve in the nasal cavity as it comes from the olfactory bulb, which is attached to the lower portion of the frontal lobe of a cerebral hemisphere (from Herrick after Wood).

sulting behavior must be due to stimulus component *Y*. Further evidence on the existence of elemental odor stimuli is gained from observing the various forms of behavior which are aroused when one odor stimulus is used continuously until complete fatigue results. Under these conditions first one response and then another is made which would normally be called forth by other stimuli than the one presented. It seems probable that these changes in response are due to the successive fatigue of the receptor for component odor stimuli.

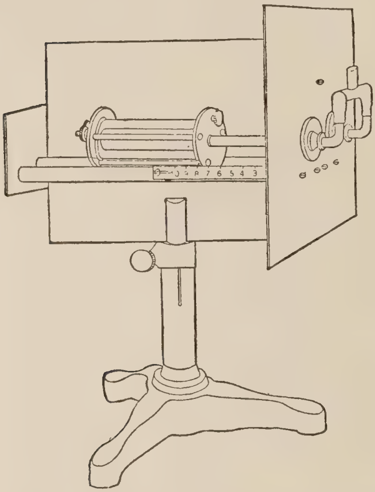


FIG. 49.—An olfactometer. The odorous substances are placed in the cylinders which slide above the scale. A glass tube projects into each cylinder and conducts the odor in varying intensity to the subject's nose.

The study of olfactory sensitivity has been carried out largely with the olfactometer (Fig. 49). The principle of the apparatus, which is due to Zwaardemaker, is that the intensity of the stimulus is proportional to the area of the diffusing surface which extends beyond the glass tubes shown in the figure. The following phenomena are the chief ones observed in studies with this apparatus. If one stimulus is conducted to one nostril and another to the other nostril, either of three results may be secured: (1) The subject may give a response which would ordinarily be given to some third stimulus but would not be given to either of the two that are present. (2) The subject may give none of the responses which he has learned to make to olfactory stimuli. (3) The subject's behavior may be controlled first by one and then by the other of the two stimuli (rivalry). Which of the three results is secured will depend partly upon the particular

stimuli chosen and partly upon their relative intensities. In these cases where the two odors are conducted to different nostrils, they affect receptors whose nerve supplies go to different sides of the brain. No fusion in the receptor can take place.

Cutaneous Sensitivity.—Cutaneous sensitivity is the term applied to the sensitivity of those receptors which lie either in or just beneath the skin. Figure 50 shows the types of receptors involved. To these should be added the free nerve endings in the superficial layers of the skin and the nerve terminations about the roots of the hairs. It is generally assumed that the end organs of Ruffini and of Krause are stimulated by changes in temperature, that the free nerve endings are affected by such stimuli as prick and injury, and that the Pacinian and Meissner corpuscles and the nerve endings about the roots of the hairs are stimulated by pressure. Such a correlation between stimulus and receptor is very difficult to substantiate because the receptors are microscopic in size and are much intermingled in the tissue. There are, however, such facts as the following to support the correlation: The free nerve endings are particularly numerous in the cornea of the eye (the clear surface covering the iris and pupil), and stimulations of this area by any form of contact or prick arouses protective reflexes and, when accompanied by the proper "instruction stimulus," the verbal response "pain." On the other hand, an area on the inside of the cheek lacks these nerve endings, and the before-mentioned responses cannot be aroused from this area. The end organs of Krause are especially numerous on the inner surface of the eyelids, on the white of the eye, and on the forehead. From these areas it is particularly easy to arouse behavior as a result of the application of temperature stimuli. Likewise along with the delicate sensitivity of the finger tips to contact goes an increased supply of Meissner's corpuscles.

Common sense assumes that the entire skin is sensitive, an assumption that is made partly because the objects of everyday life usually stimulate large areas on the surface of the body. If the skin

is explored point by point, however, it is found that only when certain points are stimulated will responses be aroused. These small

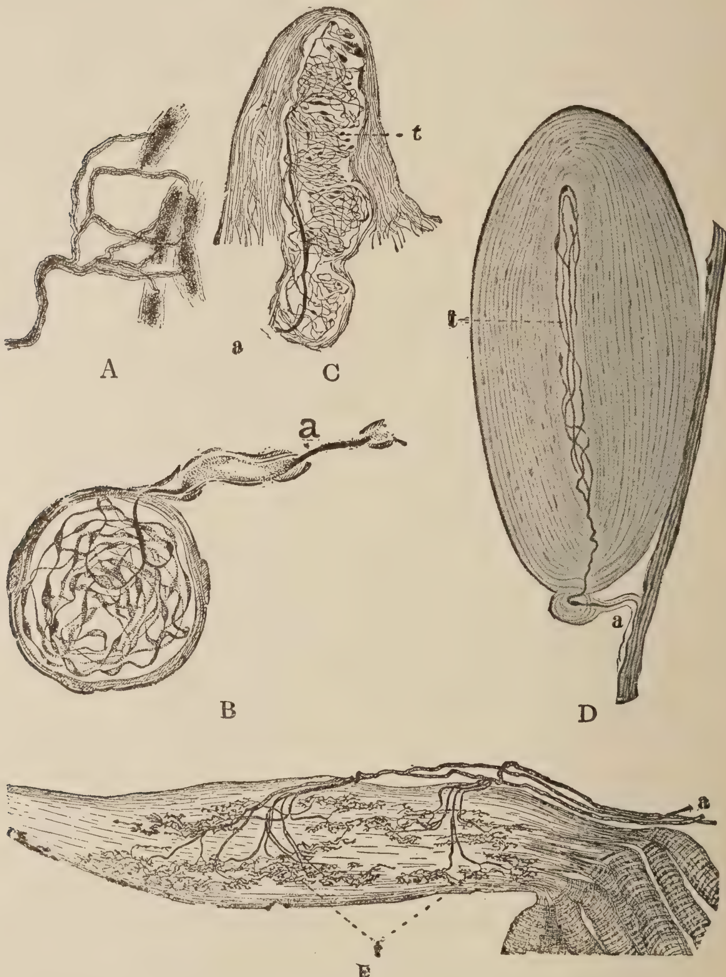


FIG. 50.—Types of cutaneous and kinaesthetic receptors (from Morris and Quain). *A*, end-organ of Ruffini, *B*, end-organ of Krause, *C*, Meissner's corpuscle, *D*, Pacinian corpuscle, *E*, nerve ending in a muscle.

areas are but rarely sensitive to more than one kind of stimulus. Figure 51 shows a map of this punctiform distribution of sensitivity as prepared by Goldscheider. It will be seen that the number of spots which can be stimulated by an increase or a decrease of temperature vary even on a small area. Experimenters have estimated that the verbal response "pain," which by training has been conditioned to the stimulus of pin-prick, can be aroused from some 2,000,000–4,000,000 spots on the body. About 500,000 spots can be stimulated by light contacts. An equal number are sensitive to

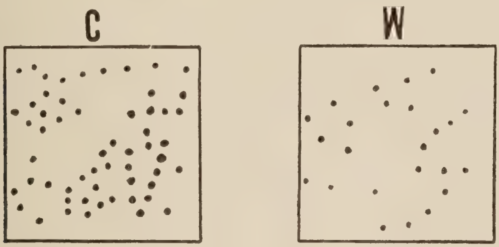


Fig. 51.—Spots sensitive to cold, *C*, and warm, *W*, on the dorsal surface of the forearm (after Goldscheider).

a decrease in temperature; and some 30,000 call forth responses when stimulated by an increase of temperature. The hairs scattered over the body act as levers to increase the force of pressure on the skin, and they also serve to decrease the area stimulated, thus making it possible to respond to stimuli which would otherwise be below the threshold of sensitivity.

The stimulus for touch, however, is not merely mechanical pressure on the skin, for if the hand is inserted in water of body temperature or in mercury, for example, the total stimulus is reacted to as though it were only effective in a ring at the upper level of the fluid. We accordingly say that a pressure gradient from low to high intensity, such as that which occurs around the edge of an object pressing upon the skin, constitutes the stimulus for the touch receptors. The stimulus for the temperature receptors is involved in too much controversy to be presented here. It is, however, bound

up fundamentally with what is termed the *physiological zero.* The physiological zero is the temperature to which any particular area of the skin is adapted, i.e., temporarily insensitive. The limits within which this may occur are usually given as 11°–39° C. Any significant increase in temperature above the momentary state of adaptation calls forth a response different from that called forth by a decrease below the state of adaptation. The customary verbal response in the former case is "warm," and in the latter case, "cold." By passing gradually from one temperature to a higher or lower and allowing the organism to adapt at each point, it is possible to do severe injury to the tissue without defensive reactions being set up.

We have usually spoken of the stimulus for the free nerve endings as pin-prick because this is a typical stimulus used in the experimental arousal of behavior from these receptors. The stimuli for the free nerve endings may perhaps be generalized as "injury to the tissue," although much injury in the way of tumors arouses none of the overt behavior usually associated with injury. The free nerve endings are often termed *noci-ceptors.* At a certain great intensity all stimuli affect the noci-ceptors. The rate at which the increase in intensity occurs is also an important condition of the phenomenon. Sudden and great increases of temperature will be effective, but the same temperature gradually attained will not. Slow pressures, on the other hand, may arouse the typical behavior to injury, whereas the rapid pressure of a knife or a bullet may not. It is also of interest in this connection to note that the nervous impulses aroused in great bodily excitement may block, more or less perfectly, those set up by injury. Thus persons may sustain severe wounds during such excitement without manifesting the behavior ordinarily aroused by injury. Injury to the viscera apparently does not affect the superficial and readily observable behavior of the subject unless the peritoneum is involved. Noci-ceptors are undoubtedly stimulated in these cases, but the nervous impulses set up fail to condition verbal responses.

The correlation of overt behavior and injury to the organism

is of great importance in medicine as well as in anthroponomy. On page 116 reference has already been made to the loss of sensitivity to injury (analgesia) in hysteria. At this point we wish to make brief mention of those unusual and abnormal cases of behavior where the subject mislocates the point of injury. In one type of case the subject behaves as though the injury were located at the terminus of a nerve when it is really somewhere along the nerve. Thus a person with an amputated foot may respond as though his foot were being injured. Such behavior is probably due to an irritation of the nerve which formerly supplied the foot. In another type of mislocation the subject behaves as though the injury were located at the terminus of one nerve, whereas the injury is really located at the terminus of another. This behavior seems to result from the transfer of nervous impulses from one pathway to another within the central nervous system. In such cases one may respond as though injured in the abdomen, when in reality eye-strain is the cause; or the subject may locate in the knee an injury which is in the teeth; or the subject may locate in the forehead an injury which is in progress in the intestines, the stomach, the uterus, etc. These types of faulty localization are due to the arousal of neural processes in the central nervous system which are normally aroused only by impulses from the receptors at the ends of certain nerves. If these impulses, however, begin midway of the nerve path, or if they are switched in over it, the central nervous changes occur as usual, with the result that the subject behaves as usual. This usual behavior, however, does not fit the changed conditions, and the subject has mislocated the injury.

Since 1905 there has been a well-defined tendency to regroup cutaneous sensitivity, as we have described it, into *epicritic* and *protopathic*, with an additional subcutaneous class of *deep sensitivity*. This classification was proposed by Head and Rivers on the basis of experiments performed upon Head himself. After cutaneous sensitivity over a certain area of the hand and forearm had been carefully tested, the sensory nerve which supplies that area of the skin was cut and the ends carefully sutured together. As the nerve

regenerated, careful studies were made of the returning sensitivity on the abnormal skin area. The following results were secured: (1) Deep sensitivity was not disturbed by the operation. The stimulus used to test this deep sensitivity was heavy pressure. The subject responded as usual to such a stimulus, i.e., partly as a result of the activity of pressure receptors and partly as a result of the activity of noci-ceptors. These stimuli were accurately localized by Head. (2) Protopathic sensitivity (called by these students the primitive cutaneous sensitivity) remained in certain areas where the epicritic was gone; and in those areas where both were destroyed it reappeared first. It included sensitivity to extreme cold and warm stimuli and to medium intensities of touch and prick stimuli. All of these stimuli were poorly localized by the subject. (3) Epicritic sensitivity, determining responses to light touch, slight changes in temperature, and light prick, was the last to return. These stimuli were well localized. Other investigators, notably Franz and Boring, have studied the question and have secured data confirmatory in general of the facts as given here.

Kinaesthetic and Organic Processes.—Very little is known concerning the afferent neural processes set up from the receptors lying in the muscles, joints, and tendons. These kinaesthetic receptors are activated by the tensions involved in muscular movement. These receptors are presumably involved in the maintenance of muscle tonus, and they probably contribute a part of the sensory control involved in such a series of muscular movements as walking, writing, or running the maze.

The viscera contain a variety of simple receptors of the order of free nerve endings and simple knobs, which are stimulated by muscular and glandular activity, and, in disease, by inflammation, pressure, and other abnormal changes in the physiological processes. We have already discussed the possible rôle of the visceral, organic, receptors in the control of instinct in chapter iii. In the present section we shall further consider these receptors through the presentation of work done on the problem of stomach activity in conditions of hunger.

The experiments of Cannon and Carlson are the most interesting. A small rubber balloon is attached to a stomach tube and is then swallowed. The balloon is inflated sufficiently to fill the empty stomach, and the free end of the rubber tube is attached to a tambor whose marker writes upon a smoked drum (Fig. 52). Whenever the stomach contracts, a puff of air is transmitted to the tambor and the marker records on the surface of the drum. The subject who has swallowed the balloon has a signal key attached to another

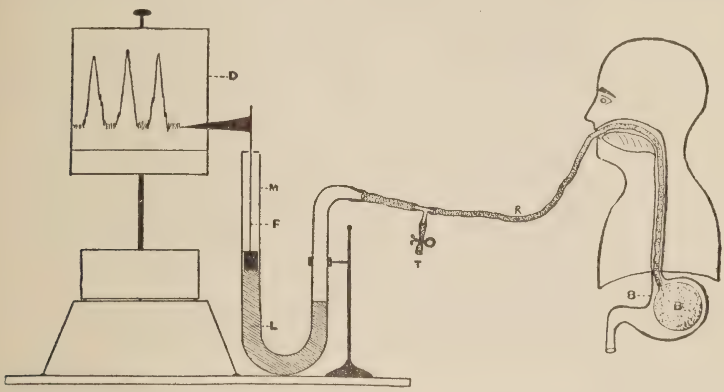


FIG. 52.—"Diagram showing method of recording gastric hunger contractions of the empty stomach of normal persons. *B*, rubber balloon in stomach. *D*, kymograph. *F*, cork float with recording flag. *M*, manometer. *L*, manometer fluid (bromoform, chloroform, or water). *R*, rubber tube connecting balloon with manometer. *S*, stomach. *T*, side tube for inflation of stomach balloon" (after Carlson).

marker. He is instructed to signal with his hand on this key whenever he would normally say, "I have a hunger pang." In addition a record of breathing and a time-record in seconds are registered on the drum. These various data are shown in the sample given in Figure 53. It will be seen that the hand reactions (called *hunger pangs* in the figure) are paralleled by the stomach contractions, a condition which has been so extensively confirmed by Carlson and his students that it may be regarded as an established fact that the stomach (and probably the oesophageal) contractions are the stim-

uli which, acting through the visceral receptors, set off the manual responses, the verbal responses "I am hungry," and the restless movements of animals when the normal feeding time arrives. The nerve involved in the control of this activity is the Xth cranial nerve, the vagus. The cortical center is probably the post-Rolandic

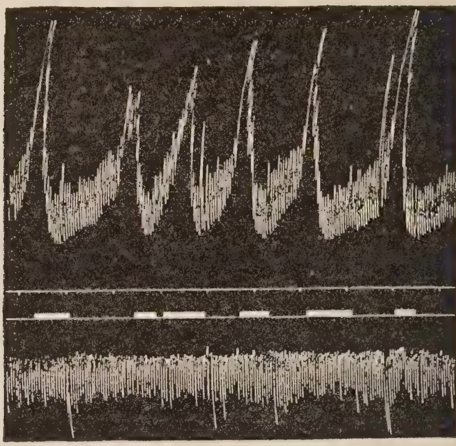


FIG. 53.—"One-half the original size. The top record represents intragastric pressure (the small oscillations due to respiration, the large to contractions of the stomach); the second record is time in minutes (ten minutes); the third record is W's report of hunger pangs; the lowest record is respiration registered by means of a pneumograph about the abdomen" (from Cannon).

area, although some evidence points to the hippocampus. Physiological changes in the blood and the absence from the stomach of material whose presence has inhibited the contractions are probably the stimuli which in their turn arouse the stomach contractions.

REFERENCES

BORING, E. G. "The Thermal Sensitivity of the Stomach," *Amer. Jour. Psych.*, XXVI (1915), 485–94.

———. "Cutaneous Sensation after Nerve Division," *Quart. Jour. Exp. Physiol.*, X (1916), 1–95.

Cannon, W. B. *Bodily Changes in Pain, Hunger, Fear, and Rage* (New York, 1915).

Carlson, A. J. *The Control of Hunger in Health and Disease* (Chicago, 1916).

Carr, H. A. "Head's Theory of Cutaneous Sensitivity," *Psych. Rev.*, XXIII (1916), 262–78.

Head, H., Rivers, W. H. R., and Sherren, J. "The Afferent Nervous System from a New Aspect," *Brain*, XXVIII (1905), 99–115.

———, and Rivers, W. H. R. "A Human Experiment in Nerve Division," *Brain*, XXXI (1908), 323–450.

———. *Studies in Neurology.* 2 vols. (London, 1920).

Herrick, C. J. *Introduction to Neurology* (Revised; Philadelphia, 1927).

Titchener, E. B. *Textbook of Psychology* (New York, 1908), pp. 471–505.

Watson, J. B. *Psychology from the Standpoint of a Behaviorist* (New York, 1919).

Woodworth, R. S. "Psychological Data Pertaining to Errors of Observation," *Internat. Critical Tables*, I (1926), 92–95.

CHAPTER V

RECEPTOR PROCESSES (*Continued*)

AUDITORY SENSITIVITY

Stimuli.—In the language of everyday speech, the stimuli for the auditory receptor are tones and noises of varying degrees of complexity. From the standpoint of physics the auditory stimuli are usually in the form of vibrations in the air. Figure 54 illustrates these vibrations, in the form of alternate condensations and rarifactions of the air, as set up by a vibrating bell. Such vibrations can be described and analyzed more conveniently when they are translated into a form comparable to waves on the surface of water. These vibrations are then readily seen to possess the characteristics of wave-length, amplitude, and form. The wave-length, which is the distance between two similar points on the waves, varies with the frequency of the vibration. Where the wave-length is long, the vibration rate is slow; where the wave-length is short, the vibration rate is rapid. The amplitude of the vibration is the maximal amount of displacement from the point of rest. The form of the wave will depend upon the elementary components of the wave. Any body which executes a simple periodic vibration will generate a simple wave, termed a sine wave. A complex wave can be analyzed into simple waves. We may therefore say that the form of any given sound wave will depend upon the relative intensities and frequencies of its simple components. In addition to air vibrations, vibrations in the bones of the head serve as stimuli for the auditory receptor.

Receptors.—The essential end organ affected by periodic air vibrations is the hair cells in the cochlear canal of the ear where the auditory branch of the VIIIth cranial nerve terminates. The cortical center most intimately connected with this portion of the ear is

in the superior, or upper, portion of the temporal lobe of the cerebrum. Prevailing opinion applies the same statement to aperiodic stimuli, although it is not certain that these stimuli may not affect hair cells in the saccule and the utricle (structures in the inner ear).

The reader must rely upon a study of models and upon his instructor's presentation for a knowledge of the anatomy of the ear. Figures 55, 56*A*, and 56*B* will, however, if carefully studied, give much preparatory information. The semicircular canals, saccule, and utricle, whose locations are shown in the accompanying figure,

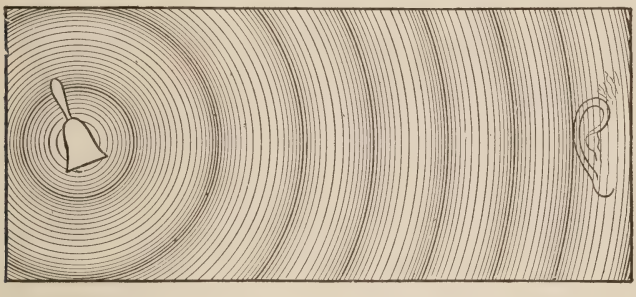


Fig. 54.—Alternate condensations and rarefactions in the air set up by a vibrating body.

are connected through the vestibular branch of the VIIIth nerve with the cerebellum. They function in aiding the maintenance of bodily equilibrium and constitute the static receptors. The canals are particularly active in rotary motion, and the saccule and utricle are said to be stimulated by motion in a straight line. In either case the motion of the body stimulates small ciliated sensory patches in the structures mentioned, the immediate stimulation being due to the inertia of the fluid and calcareous particles found about those receptors. When the body moves these substances lag behind and in this way affect the receptors. The three structures we have mentioned are termed the vestibular portion of the ear. Chief interest, however, centers upon the cochlear portion of the ear, which we shall now consider.

Air waves pass down the external acoustic meatus and set the tympanum (ear drum) in vibration. These vibrations are transmitted by the three bones of the middle ear (hammer, anvil, and stirrup) to a membranous window leading into the inner ear. Here the vibrations proceed for a short distance through a liquid in the

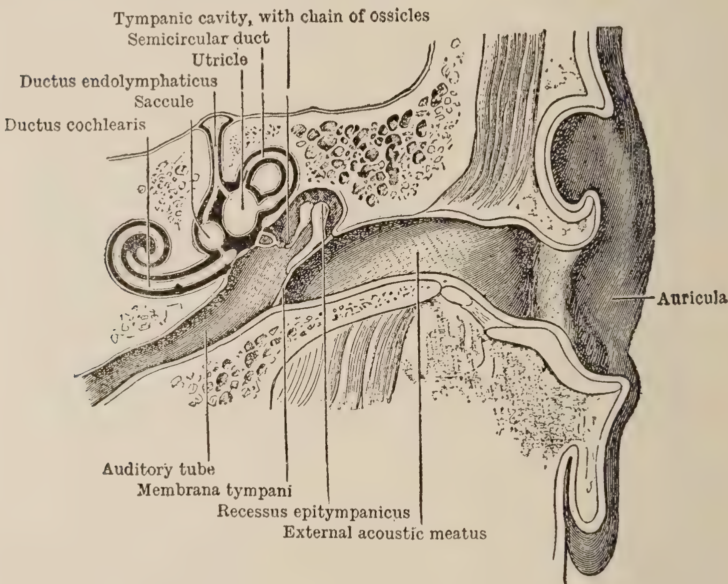
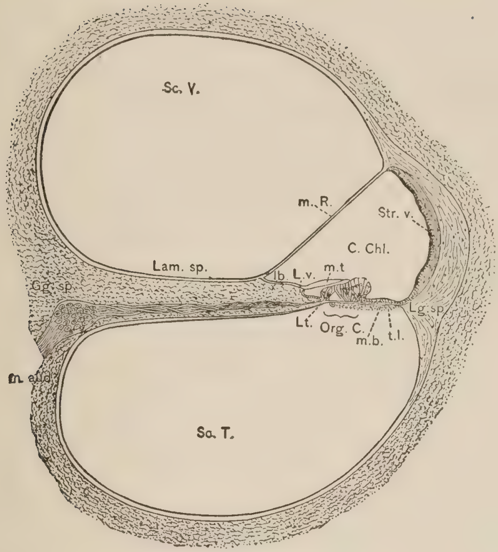
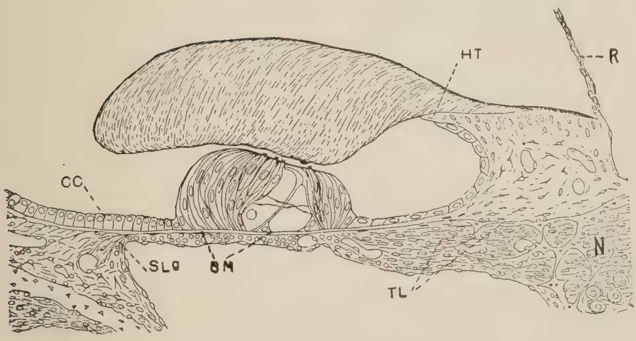


FIG. 55.—A diagrammatic view of the ear (from Cunningham)

scala vestibuli; or if the vibration is intense they may pass to the end of this passage. Onward in their course the vibrations are transmitted through Reissner's membrane, through the cochlear duct, and into the *scala tympanum,* finally spending themselves in the vibrations of a membranous window (the round window) which opens back into the middle ear. Certain structures in the cochlear canal are thrown into vibration, thus starting activities in the hair cells. By this means a nervous impulse is initiated in the fibers of the VIIIth nerve, over which it then passes to the central nervous



A



B

Fig. 56.—*A*, typical cross-section of the cochlea (from Calkins after Foster). *Sc. V.* is the scala vestibuli, shown in black above the cochlear duct in the preceding figure; *m. R.*, Reissner's membrane; *C, Chl.*, cochlear duct, or canal; *m. b.*, basilar membrane; *m. t.*, tectorial membrane; *Org. C* , organ of Corti; *Sc. T.*, scala tympani; *n. aud.*, auditory nerve; *Gg. sp.*, spiral ganglia containing the cell-bodies of the neurones making up the auditory nerve.

B, a cross-section of the cochlear duct of a pig showing: *HT*, tectorial membrane, hair cells and rods of Corti just below and resting upon *BM*, the basilar membrane. Notice that this membrane has a layer of cells on each side of it which would interfere with its free vibration. *R* is Reissner's membrane. The fibers of the auditory branch of the VIIIth nerve pass through the region marked *N* (modified after Hardesty).

system. Although the preceding account is fairly complicated, it is absolutely essential if even the rudiments of the ear's activity are to be understood.

Theories of Auditory Sensitivity.—Theories of auditory sensitivity deal with the probable activities in the cochlear canal which are set up by the various aspects of the stimulus. The most conspicuous theory that we have was advanced by Helmholtz. He assumed that the transverse fibers of the basilar membrane are keyed to different pitches. These fibers are supposed to respond by sympathetic resonance to vibrations in the air and ear-fluids much as one tuning-fork will sound when another of the same pitch is active in its immediate vicinity. The vibration of the fibers of the basilar membrane stimulates the hair cells, and in this way the nervous impulse is started. In support of this theory it is known that there are transverse fibers of various lengths in the basilar membrane, and there is some evidence indicating that the broad end of the membrane is activated by vibrations of low frequency. The chief objection to the theory, however, is anatomical, for the transverse fibers are not free to vibrate, but are interlaced with longitudinal fibers and covered on both sides with cell layers, as shown in Figure 56*B*. Against this fact the simplicity of the theory should have no weight.

Shambaugh and Hardesty have presented important contributions indicating that the tectorial membrane is the structure which by vibrating stimulates the hair cells. Hardesty has constructed a large model of the cochlear canal and has shown that an artificial tectorial membrane will be set in activity by vibrations in the air and endolymph. Ewald has presented similar evidence indicating that the basilar membrane may be set into activity in ways other than that described by Helmholtz. However, the anatomical measurements made by Hardesty favor at present the major influence of the tectorial membrane.

Discriminative Behavior to Simple Auditory Stimuli.—The human subject in his normal life-activities learns to make different verbal and non-verbal responses to differences in the frequencies,

amplitudes, wave forms, and location of auditory stimuli. Like all other forms of behavior these discriminative responses can be greatly improved through specific training. We do not know what the limits of discrimination are for the untrained subject, but we have reasonably dependable data for trained laboratory subjects.

With relatively simple tones which can be analyzed into an approximation to a simple periodic disturbance of the air, the lowest vibration frequency which can arouse verbal responses through the auditory receptor is eighteen complete vibrations (d.v.) per second. This value, of course, is an average of a distribution of values. It can be lowered somewhat by increasing the amplitude (intensity) of the stimulus. The highest vibration frequency which can arouse the before-mentioned responses is between 15,000 and 22,000 complete vibrations per second. It is possible that studies made with the conditioned reflex method would show that the auditory receptors could be affected by stimuli which lie outside of the range just indicated. Within the auditory range of a given subject it is not unusual to find certain tonal stimuli which have no effect upon behavior. The subject is, to all intents and purposes, insensitive to these stimuli. Such gaps in the auditory range are termed tonal gaps.

Simple auditory stimuli such as are produced by gently struck tuning forks cannot be well localized by the human subject. (We have no extensive data on this problem for the infrahuman animals.) We shall discuss this general problem of the localization of stimuli later in the present chapter. Here we only need note the fact, with reference to simple auditory stimuli, that the subject cannot be trained to respond accurately either with words or by manual pointing to the location of such stimuli.

The trained subject can make discriminative responses to many degrees of difference in the amplitudes of simple tonal stimuli. There is good reason for believing that the greater the amplitude of a given stimulus, the more must that amplitude be increased before the subject can discriminate between the two stimuli. (This is the phenomenon formulated in Weber's law.) The amount of

increase approximates a percentage which is constant throughout the middle portion of the auditory range.

Discriminative Behavior to Complex Auditory Stimuli.—Practically all tonal stimuli encountered in the course of daily life are complex, i.e., they are physically analyzable into simple tonal stimuli whose wave forms are sine curves. We may state this in another way. Practically all vibrating bodies vibrate not only as wholes but also in parts. The vibration of the body as a whole

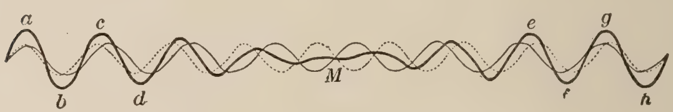


FIG. 57.—Interfering air-waves. The amplitude is one-half the distance between the top and bottom of the curves. The form of the wave is its contour. Wave-length is the distance horizontally between any two homologous points on the curve. There are eight complete wave-lengths in one of the fainter curves and nine in the other. The heavy curve is the result of the combination of the other two. There is almost a cancellation of amplitudes (intensity) in the center of the figure. This in comparison with the ends of the curve gives the stimulus basis of a beat.

gives an air wave of lower frequency than does the partial vibration. These total and partial vibrations, as they occur in a vibrating string, are illustrated in Figure 57.

The discriminative behavior of which the human subject is capable with reference to complex auditory stimuli is dependent upon (*a*) the nature of the stimuli and (*b*) the nature of the receptor or neural processes which arise when the end organ is affected by these stimuli. For information concerning the nature of these latter processes we must at present depend upon hypotheses. What specific behavior shall be aroused by complex auditory stimuli will, of course, be the result of the previous training of the subject, as is the case with reference to the stimuli for the other receptors. He may make verbal or non-verbal responses. He may talk, sing, typewrite, or run. Our concern in the present discussion

is not with *what* behavior can be aroused, but with the stimulus-receptor processes which underlie *any* behavior to auditory stimuli.

Let us consider the before-mentioned factors, *a* and *b*, in terms of concrete stimulus conditions. If two tuning forks, each of a vibration frequency 256 d.v., are sounded simultaneously, the subject will respond in the manner in which he has been trained to respond to a stimulus from a single fork of 256 d.v. This response will depend primarily upon the wave-length of the stimulus, if we have inhibited other types of response, such as those to amplitude and wave form, in the subject by means of suitable instruction stimuli. Suppose we now place a sliding weight upon the prongs of one fork, and by this means gradually reduce its vibration frequency from 256 d.v. to 128 d.v. The two forks are still to be sounded simultaneously and with about equal intensity, or amplitude. As the difference between the vibration frequencies changes from 0 to about 80 d.v. per second, the subject behaves as he has been trained to behave when stimulated by a single 256 d.v. fork which sounds now softly and now loudly. He does this in spite of the fact that the two forks are actually sounding at a constant intensity. The explanation of this change in behavior lies in the interference of the air waves outside of the ear, as shown in Figure 57. Although the two forks are vibrating through equal amplitudes, the air waves which affect the ear show periodic changes in amplitude. The frequency of these changes in amplitude is determined by the difference in vibration rate of the two forks.

When the difference in vibration frequency of the two forks is about 80 d.v. per second, a subject who has been trained to respond to a tonal stimulus of 80 d.v., even though it be sounded simultaneously with other tones, will respond *as though* his ear were stimulated by a vibration frequency of 80 d.v. in addition to the two primary frequencies. However, the presence of such a stimulus outside the ear cannot be verified. At times, when stimulated by two forks as just described, trained subjects may respond as if stimulated by several tones whose presence outside the ear cannot be verified. Thus when our two forks differ in vibration frequency

by 128 d.v., the trained subject may respond, not only to either of the two forks actually sounding, i.e., the vibration frequencies of 256 and 128, but also as though stimulated by the tones 274 d.v. and 384 d.v. and also as though the 128 d.v. fork had an increased amplitude. Careful studies of phenomena of this type have led to the conclusion that the stimuli which *seem* to control behavior, but whose presence outside the ear cannot be verified, can be calculated by the formulas given and illustrated in Table V. The most reason-

TABLE V

FORMULAS FOR DETERMINING THE VIBRATION FREQUENCIES OF EXTERNALLY NON-VERIFIABLE STIMULI WHICH ARISE WHEN TWO PRIMARY FREQUENCIES ARE USED AS STIMULI. ILLUSTRATED WITH TWO SETS OF PRIMARY FREQUENCIES

Formulas	Primary Frequencies: 256 d.v. and 128 d.v.	512 d.v. and 640
	Derived Frequencies	
h−l	128	128
2l−h.........	256−256=0	1024− 640=384
3l−2h........	384−512=128	1536−1280=256
4l−3h........	512−768=256	2048−1920=128
4h−5l........	1024−640=384	2560−2560=0

able explanation at the present time for these externally non-verifiable stimuli is in terms of processes in the ear. The two external stimuli apparently cause vibrations in some of the structures of the middle or of the inner ear, which then become in their turn sources of stimulation.

The receptor processes determining behavior to simultaneous auditory stimuli are enormously complex in virtue of the accessory disturbances set up in the ear by the external stimuli. Most external vibrating objects produce not only total but also partial vibrations, and the accessory stimuli indicated by the formulas of Table V may arise not only between each two total vibrations but also between each two partial vibrations and between each partial

and each total vibration. Only highly trained subjects can give discriminative behavior to the details of the situation as we have set them forth.

The usual subject, when he presents himself for experimentation, has already learned to discriminate between the tone 256 d.v. sounded on one instrument, e.g., the piano, and a tone of the same frequency and amplitude sounded on another instrument, e.g., the violin. An analysis of these two tones reveals the fact that they differ partly in wave form and partly in certain aperiodic vibrations, noise, which accompany them. This latter fact is illustrated in the thumping that activates the piano string and the scraping that sets the violin string in motion. The former fact arises from the difference in the partial vibrations set up in the two strings. Even after experimentally excluding the accessory aperiodic stimuli, subjects may be trained to make fine discriminations on the basis of the differences of wave form which arise from various combinations of total and partial periodic vibrations.

No account of auditory sensitivity would be complete if nothing were said about the field of music. Although this topic concerns social behavior, we shall comment upon it here. Music represents the most highly socialized and institutionalized form of auditory stimulation. Different peoples and different social groups have conventionalized their music in different ways using different vibration frequencies, different wave forms, and different rhythms, i.e., different combinations of stressed and unstressed tones. Western European music utilizes primarily only tones where the vibration frequencies between any two tones stand in the following ratios one to the other: 1:2, 2:3, 3:4, 4:5, 5:6, 3:5, 5:8, 8:9, 15:16, 8:15, and 9:16. Vibration frequencies which stand in the foregoing ratios one to the other not only afford a basis for discriminative behavior between pairs but they differ in the accuracy with which the members of each pair can be descriminated one from the other. We have listed the ratios in the order of the increasing ease of discrimination between the component tones of

the pair. Thus 256 d.v. and 512 d.v. are in the ratio 1:2, and 256 d.v. and 384 d.v. are in the ration 2:3. Although a subject may be trained to give different responses to 256 d.v., 384 d.v., and 512 d.v. when they are presented separately, he is less accurate in giving first one and then the other response when the tones 256 d.v. and 512 d.v., or the tones 256 d.v. and 384 d.v., are presented simultaneously. Moreover his accuracy is less in the latter than in the former case. Tones standing in the ratios just given are combined simultaneously into stimuli named harmonies and successively into stimuli named melodies.

We do not know enough about the visceral behavior which may be aroused by the harmonies and melodies of music to discuss the problem profitably. We do know, however, that these socially accepted stimuli are presented to the individual in a great variety of situations from birth to death, situations which involve resting, working, nursing, sleeping, dancing, loving, fighting, fleeing, etc. Musical stimuli thereby become conditioned to a great variety of responses which may then be explicitly aroused by it. To what extent the responses may also be implicity aroused we do not know.

Complex auditory stimuli may be produced in man directly by vocal behavior and also indirectly by manual behavior. This self-excitability of the receptors is one of the chief factors making possible the socialization of auditory stimuli either in the form of music or of language. The science of human behavior has accumulated a very respectable amount of dependable data upon the capacity of a human subject to produce definite vibration frequencies orally, to sustain these tones, to introduce vibrato, and to vary orally the factors in tone which are involved in musical stimuli. Space, however, will not permit us to present this material, although it is of prime importance for the understanding of man's behavior to auditory stimuli.

VISUAL SENSITIVITY

Receptors.—The essential receptors for vision are the rods and cones of the retina of the eye. Figure 58 represents the eye as a whole and Figure 59 gives the detailed structure of the inner (reti-

nal) coat. Rays of light pass through the cornea, acqueous humor, lens, vitreous humor, and strike upon the retina. This latter, how-

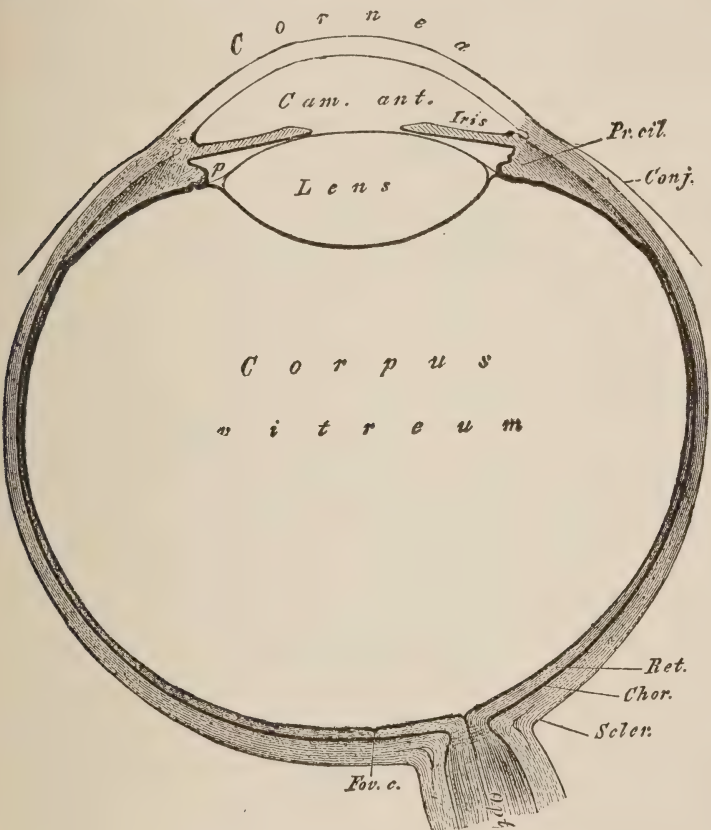


FIG. 58.—Horizontal section through the left eye (from Angell). The optic disk is the portion of the retina at the entrance of the optic nerve. *Pr. cil.* indicates the ciliary process or muscle, *conj.*, conjunctiva; *ret.*, retina; *chor.*, choroid; *scler.*, sclerotic; *fov. c.*, fovea; *cam. ant.*, the anterior chamber filled with a transparent aqueous humor; *corpus vitreum*, the vitreous humor filling the posterior chamber.

ever, is transparent, and the rays pass through the ganglion-cell layer, the bipolar layer, the rod and cone layer (shown in Fig. 59),

and set up chemical changes in the outer segments of the rods and cones. These changes start nervous impulses which pass through the layers of the retina, out over the optic nerve to the thalamus and the mid-brain. From here the impulses may make many reflex connections or they may go to the occipital lobe of the cerebrum

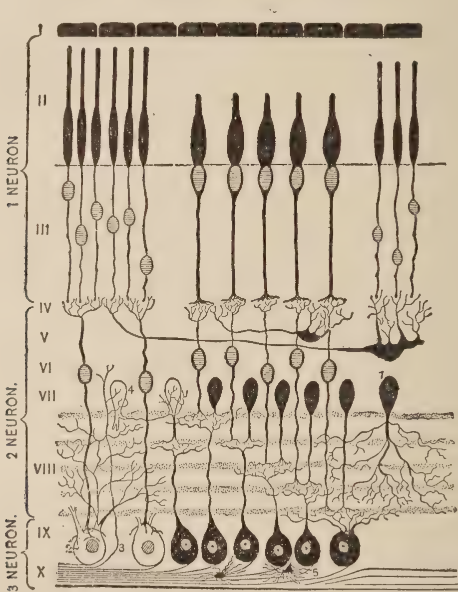


FIG. 59.—Diagram of the detail of the retina (from Howell). *1* is the choroid coat; *1 neuron* includes rods (slender) and cones; *2 neuron* indicates the bipolar layer; *3 neuron* indicates the ganglion cells and their axones which go to form the optic nerve; *X* is composed of fibers which make up the optic nerve after they leave the eyeball.

and so influence highly variable behavior. The *optic disk,* in which are found neither rods nor cones, but only fibers, is found at the point where the optic nerve enters the eye. It is insensitive to stimulation.[1] The *fovea* is the retinal area of greatest sensitivity.

[1] The reader should demonstrate this for his own satisfaction. Take two pieces of white paper 1 cm. square, hold them side by side about 18 inches

It subtends an angle of 55′–70′ from the nodal point (about the center of the lens); or, in other terms, it is 0.2–1.0 mm. in diameter. There are no rods here, only cones. From the fovea as a center to the periphery of the retina the rods gradually increase in number relative to the cones until on the extreme periphery very few cones are present. The choroid, which underlies the retinal layer, is a black pigmented coat that serves primarily to absorb the rays of light, thus preventing reflection within the eye. The third and last layer is the sclerotic coat, which is tough, fibrous, and practically opaque in man. It serves to hold the eyeball in shape and to keep out the light. The adjustment of the eye to the location of an object is accomplished by two muscular mechanisms: (1) six muscles are attached to the outer surface of the sclerotic and serve to move the eye in the socket; and (2) the ciliary muscle inside the eye varies the tension on the lens, thus flattening it for far vision, or permitting it to bulge for near vision (see Fig. 60). The latter muscle is a part of the mechanism of accommodation and aids in securing a sharp image of the stimulus upon the retina. Changes in the contraction of the muscles of the iris vary the size of the pupil and also aid in the formation of a clear retinal image.

Stimuli.—The normal stimulus for the visual receptors is light, either white or colored. Light, when analyzed by the physicist, is shown to possess the characteristics of wave-length, intensity, and duration. The light given off from such sources as the sun, electric arcs, and mazda lamps is composed of a great variety of wave-lengths which may be separated one from the other by passing the

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from the eyes. Close the left eye and fixate the left paper with the right eye. Now gradually move the right paper farther to the right, keeping the eye fixed on the stationary one. Soon the right paper will fall within the area of the blind spot. By moving the paper about (right to left and up and down) the exact outlines of the spot can be found. The blind spot is really a blind *cone* extending into the distance with the apex at the eye. Very large objects, if far enough away, will be invisible when they come within the cone. To find the blind cone with the left eye, close the right eye and fixate the proper object with the left eye.

light through a refracting prism. The spectrum which results from this breaking up of white light is composed of bands of colored light. These bands are relatively monochromatic, i.e., each band is composed of essentially one wave-length. Those wave-lengths which lie between 397 $\mu\mu$ and 760 $\mu\mu$[2] include all of the light which serves as the normal stimulus for the visual receptors. The longer non-effective waves lie in the region of the infra-red, and the shorter non-effective waves lie in the region of the ultra-violet light. The intensity, or energy, of light is determined by its chemical and

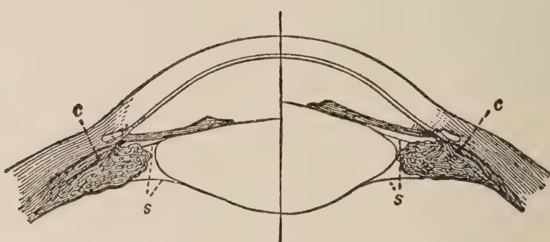

FIG. 60.—Variation in shape of lens during accommodation; *s*, suspensory ligament; *c*, ciliary muscle.

electrical effects. Light stimuli affect human behavior not only in relation to their wave-lengths and energy but also, as do most other stimuli, in relation to their duration and to their locations. Our problem in the following sections is to indicate the elementary discriminative behavior which arises in man in virtue of the nature of light and the nature of the visual receptor.

Discriminative Behavior to White Light.—The normal human subject readily learns to make one type of response to white light and another type of response to colored light. Concerning the history of this learning in any particular individual we are quite ignorant. In the study of human adult behavior our subjects come to us with the foregoing types of behavior already established. Not only do they have this behavior equipment, but they have also

[2] Millionth of a millimeter.

acquired a great variety of responses to differences in wave-length and in intensity. Our experimental study of visual sensitivity makes use of these responses, and, if necessary, new responses are taught the subject.

The verbal response "white," or any non-verbal response which the subject has learned to make to such lights as sunlight, can be aroused by a variety of stimuli. (1) In the first place, it can be aroused by light of heterogeneous wave-length, unless the light is too faint to affect the visual receptor. (2) If we start any monochromatic light, i.e., a light of a single wave-length, at zero intensity and increase it to its maximum intensity the subject will at first respond as if stimulated by white light. The response will then change to that aroused by the monochromatic light, let us suppose it to be red light. When the very high intensities are reached the subject will again make the response which he has learned to make to white light. Colored light at low intensities calls forth, therefore, the same response as does white light, and cannot be discriminated from it. It makes no difference whether a faint light is used close to the subject or an intense light is used at a great distance from him. (3) White light responses can also be called forth by using a suitable mixture of monochromatic lights or by applying the monochromatic lights to the peripheral portion of the subject's retina. These two conditions are of sufficient importance to warrant our devoting separate paragraphs to their description.

Behavior to Color Mixture.—The color mixture to which we refer is not truly mixture. Two overlapping color discs, e.g., red and blue-green, are placed upon a spindle rotated by a motor. When the motor is started and the discs rotated, the red light stimulates a given area of the retina for a certain time and then blue-green light stimulates the *same retinal area* for a certain time, then red, then blue-green, etc. The relative length of time during which the red stimulus affects the retina is determined by the amount of the red disk which is displayed on the spindle. If there are 180° of red and 180° of blue-green, each affects the retinal area one-half

the time. If the proper proportion of red and blue-green are chosen, and if the spindle is then rotated rapidly, the subject will respond as he has been trained to respond to white light. For every color another color can be found which, if alternated rapidly with the first in such a manner as to stimulate successively the same retinal area, will call forth the response usually aroused by white light.

Behavior to Extreme Peripheral Retinal Stimulation.—The remaining method by which "white light responses" may be elicited is by the application of colored light to the extreme periphery of the retina of a trained subject. All spectral lights and combinations of spectral lights, when of not too great intensity, arouse from the periphery of the retina only those responses which the subject has been trained to make to white light. This is another way of saying that, with stimuli of low or medium intensity, no discriminative behavior to differences in wave-length can be conditioned from the periphery of the retina. We shall return to the question of peripheral sensitivity shortly in our discussion of discriminative behavior to colored light. At that time we shall describe the apparatus and methods used in the investigation of the problem.

Discriminative Behavior to Colored Light.—When the central portion of the retina is stimulated it is easy to train the human subject to discriminate between light stimuli on the basis of wave-length. The spectral limits of this discrimination are marked by red and violet light whose wave-lengths we gave in the section on "Stimuli." Many of the responses to different wave-lengths have been conventionalized in language, e.g., red, green, blue, mauve, orange, cerise, etc., but the number of stimuli which can be discriminated is much larger than the number for which any social group has devised verbal responses. The human subject can be trained to say "yes" or "no," "same" or "different," to a bewildering number of color stimuli. These color stimuli are secured by varying wave-lengths and intensities, by combining various wave-lengths so that they stimulate the same retinal area simultaneously or in rapid succession, and by mixing various amounts of white light with the colored light. In establishing these discriminative

responses in the subject, of course, the experimenter need not depend upon such verbal behavior as "yes" and "no." The subject may be taught to respond non-verbally with almost any set of skeletal muscles, making one response for one stimulus and another response for another stimulus. When a new pair of stimuli are chosen for experimentation the experimenter may still require the subject to say "yes" or "no" or to make the same non-verbal responses which he made before to the other pair of stimuli. The situation is quite on a par with that found in experimentation upon the infrahuman animals. We prove that an animal can discriminate between red and green by training the animal to run through the side of the discrimination box in which a red light appears. We may also prove that the animal can discriminate blue and yellow by requiring it to make the same response to the blue that it made before to the red, i.e., running through the box in a certain direction.

Although the number of colored stimuli which can control discriminative behavior in man is enormous, the number of typical phenomena involved is quite small. We shall enumerate these and discuss some of them briefly.

1. The general fact of discriminative behavior to wave-length differences and to combinations of wave-length differences with various intensities and with various amounts of white light we have already mentioned.

2. In the section on "Discriminative Behavior to White Light," we have said that when two or more properly chosen wave-lengths are made to stimulate the same retinal area in rapid succession the subject will respond as he has been taught to respond to white light. This is an *equivalence of stimuli by mixture* (see chapter vii). We find the same phenomenon in the discriminative behavior with reference to colored light. If one retinal area is stimulated in rapid succession by red light and yellow light, the subject will make the response which he has been trained to make to some one of the wave-lengths which lie between the red and the yellow. If the experiment is repeated using blue and green light, the subject will respond as he has been trained to respond to some wave-length

which lies between the length of blue and the length of green. We may generalize this as follows: The normal human subject who has been trained to give definite responses to the various wave-lengths of the spectrum will give these responses when one area in the central portion of the retina is stimulated in rapid succession by a proper combination of two or three wave-lengths chosen from the two ends and the middle of the spectrum.

3. *The determination of behavior by visual pre-exposure* is illustrated by the following case: Our subject has been trained to make one response to red and another to blue-green. If now some central retinal area is stimulated for 30 seconds with red light and then with a medium intensity of white light, the subject will give the response which he has learned to make to blue-green and not some response which he has learned for white light stimuli. In demonstrating this simple phenomenon red paper may be used for the source of the red light and white paper for the source of the white light. When the eye is pre-exposed to one stimulus this fact will determine more or less completely the behavior which will be manifested to the next stimulus. No space is available in an elementary account like this one to present the many variations and ramifications of this phenomenon. We must confine ourselves to the following statements: (*a*) If first one color stimulus and then another is used as the pre-exposure stimulus, and if a complete record is kept of the responses made to a medium intensity of white light following the pre-exposure, a very significant fact becomes apparent. The same stimulus-response relationships occur here which we have found in the case where two colored stimuli, presented in rapid succession, evoke a response as if to white light. *Such stimuli are termed complementary stimuli.* Red and blue-green, yellow and blue, orange and a certain blue-green are complementary stimuli. In the phenomenon of pre-exposure effects the same stimuli are linked. Thus, if the eye is stimulated through a pre-exposure to red and then stimulated by white light of medium intensity the subject responds as if stimulated by blue-green light. If the pre-exposure is to blue, the subject later responds as he has

been trained to respond to yellow, etc. (*b*) The after-effect of the pre-exposure is independent of the position of the eye. For example, after pre-exposure to a blue light which comes from one wall of a room the subject will respond as though stimulated by a yellow light coming from any direction in which he turns his eyes. He will even make this response when his eyes are closed.

There is another type of behavior conditioned by pre-exposure which must be mentioned. When a stimulus acts upon the eye the subject makes some response, *R*, to which he has been trained. For a brief interval of time after the pre-exposure stimulus has been removed the trained subject will continue to respond with *R*, as if the stimulus were still acting upon his eye.

4. *The determination of behavior by visual background* involves a relationship between those complementary stimuli which we have already described. The response made to any visual stimulus is partly a function of the background upon which the stimulus appears. If a small grey square is placed upon a red background the response made to the grey square will be the one which the subject has been trained to make to a blue-green stimulus. If the background is yellow the grey square will call forth the customary response to blue. Each visual stimulus exerts an influence upon the behavior made to neighboring visual stimuli. This influence is always in the direction of calling forth responses customarily made to the complementary stimuli. (We have not spoken of white light in relation to complementary stimuli, but white light of low intensity has essentially a complementary relation to white light of high intensity. So a red square on a white background is reacted to as though it were of lower intensity than it would be on a black background.)

5. *Behavior varies with the portion of the retina which is stimulated by colored light.* The retina is not equally sensitive throughout its extent. In the fovea and the area immediately surrounding it the retina is maximally sensitive to white and colored light. Just beyond this central area sensitivity to red and green light is practically absent, while that to blue and to yellow light

is unaffected. In the extreme periphery of the retina colored light of low and medium intensity arouses the same behavior that is aroused by white light. In other words, the extreme periphery is practically insensitive to wave-length differences in the stimuli. The instrument used in mapping the zones of different sensitivity in the retina is called a *perimeter,* one of which Figure 61 represents. The variation in sensitivity throughout the extent of the retina reminds us immediately of the way in which the rods and cones are distributed—in the fovea cones only; toward the periphery more and more rods and fewer and fewer cones. The further significance of these facts we shall comment upon later in the section on "Theories of Retinal Sensitivity."

Ferree and Rand have probably secured the best experimental control over the factors influencing the extent of the zones of sensitivity. The most important of these factors are: (1) the size of the color-stimulus, (2) the general illumination of the room, (3) the intensity of the pre-exposure (i.e., the intensity of the light which is reflected from the object which closes the aperture in the screen of the perimeter and which therefore affects the retinal area just before the color is exposed), and (4) the intensity of the light reflected from the screen, or background, surrounding the aperture. One can hardly generalize the results without some error. As a rule, however, the extent of the zones of sensitivity is less with: (*a*) a decrease in the size of the object (area of the screen aperture); (*b*) a decrease in the general illumination; (*c*) a pre-exposure which differs greatly in intensity from the color tested; and (*d*) a background which is markedly different in intensity from the color tested.

6. *The phenomenon of abnormal insensitivity to wave-length differences* is the sixth typical phenomenon which we are to discuss. We are already familiar with the fact that the normal human eye is insensitive to wave-length differences under certain conditions. Certain individuals, however, have abnormal eyes and are unable under any conditions to have their behavior controlled by the wave-lengths of light. This defect may be due to disease, or it

may be congenital, in which case it is inherited according to Mendel's law. Insensitivity to wave-length differences may be total or partial. Partial insensitivity is the more common occurrence. Those persons more insensitive to the long rays than to the short

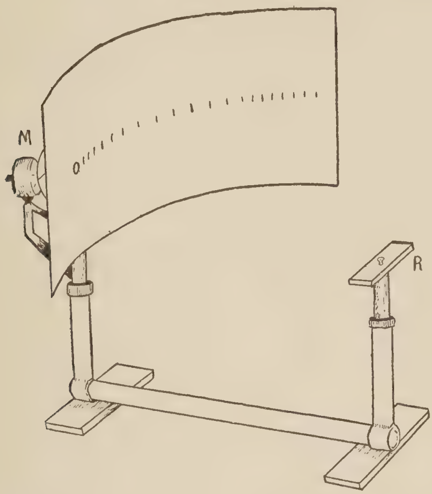

FIG. 61.—Perimeter for plotting the distribution of color-sensitivity in the retina (modified after one by Carr). *M*, motor and color-disks behind the campimeter screen. This screen and the metal closing the aperture can be of any brightness from black to white. The stimulus-color is seen through the aperture. *R*, the head-rest. The screen is arranged in the figure to test the temporal part of the right eye or the nasal part of the left eye. It can be rotated in order to test the other portions of the retina. In using this apparatus the subject moves his point of vision from the aperture to the periphery of the screen or vice versa. The color-stimulus does not move.

ones are termed by Von Kries *protanopes* (red-blind), while those less sensitive to the short rays than to the long are termed *deuteranopes* (green-blind). Occasionally one finds *tritanopes.* These individuals are unable to discriminate between blue and yellow light on the basis of wave-length differences. Such a condition is a result of disease and is very rare.

The detection of the protanopes and deuteranopes is particularly important because of the use of red and green lights on railroads and steamship lines. Two prominent methods of diagnosis are employed. One, the Holmgren wool test, is widely known and used for rough examinations. A large number of varicolored skeins of wool are placed before the subject who is instructed to place all skeins of a given hue into one pile. The protanopes ignore the element of red in the skeins and class together the reds, oranges, and yellows, and the blues and purples. The deuteranopes ignore the green element, and consequently place a greenish yellow with yellow, and a blue-green with blue. The other method, which yields more accurate data concerning the exact nature of the individual's defect, requires him to match each of the various hues of the spectrum with a combination of two wave-lengths, one selected from the red end and the other from the blue end of the spectrum. (With the normal eye such matches are only possible with three wave-lengths).

Theories of Retinal Sensitivity.—The theories of retinal sensitivity are attempts to construct the probable nature of the processes going on in the retina which underlie and condition the behavior to white and colored light which we have been describing. The most prominent theories are those of Helmholtz and Hering. The former, although many times modified, is much less tenable than the latter. Helmholtz's theory assumes that the retina contains three substances called the red, green, and violet substances. Any light ray stimulates all of these, but in unequal degrees. When all are stimulated in the proper portion, as is the case with white light and with complementary stimuli, the subject responds as he has been taught to respond to white light. If the red substance is chiefly affected, the subject responds as he has learned to respond to red light. Or we can state the matter as follows: a subject can learn to make a characteristic response to red light only because he has in his retina a substance particularly sensitive to that wavelength. The phenomena discussed previously under the topic of pre-exposure are accounted for partly by an assumed inertia of the retinal activity and partly by its fatigue. When the same be-

havior that has been made to a stimulus continues after a stimulus has been removed the theory assumes a continuation through inertia, of the retinal activity set up by the stimulus. Where complementary stimuli are concerned, the resulting behavior is explained on the basis of fatigue. Thus, when red light is the pre-exposure stimulus the red substance is fatigued, and behavior is then controlled by the activities of the non-fatigued substances. The great defect of the theory lies in the failure to provide a special mechanism sensitive to white light and to any light of low intensity.

This defect is remedied in the Hering theory. The Hering theory assumes in the retina three substances: black-white, red-green, and blue-yellow. Of these the black-white, which is the most sensitive and the most widely distributed, is affected by all rays of light and is found both in the rods and in the cones. The red-green and blue-yellow substances, however, are found only in the cones and are stimulated only by colored light. Each of the three substances has two antagonistic modes of activity underlying the two forms of sensitivity specified in the name, e.g., red-green. The behavior which results when the same retinal area is stimulated in rapid succession by two complementary color-stimuli is explained by this theory as follows: If the red phase and the green phase of the red-green substance are stimulated simultaneously with a certain relative intensity, the two antagonistic processes balance each other and no nervous process is aroused. The light, however, still affects the black-white substance, and the subject responds as though stimulated by white light. Abnormal insensitivity to wave-length differences is explained on the basis of the absence of certain of the retinal substances. The variations in peripheral sensitivity, which result in zones of different sensitivities, are said to be due to the varying distribution of the visual substances in the retina. The determination of behavior by visual pre-exposure is explained partly on the basis of inertia and partly on the assumed tendency of the retinal substances to maintain an equilibrium between their antagonistic processes. The use of inertia as a method of explanation is the same that we have described for the Helm-

holtz theory. In the other case Hering assumes that the red-green substance is in equilibrium when it is not being stimulated. When red light falls upon it the red substance is used up and the green substance becomes active until an equilibrium has been restored. Behavior thus shifts from that which red light arouses to that which green light arouses. Neither theory has a satisfactory explanation of the retinal processes involved in the determination of behavior by the background of a stimulus.

DISCRIMINATIVE BEHAVIOR TO THE SPACE CHARACTERISTICS OF STIMULI

Introduction.—The spatial characteristics of objects are size, form, extension in the third dimension, location, and movement. Objects are not always moving, but they possess the remaining characteristics at all times, whether or not these characteristics determine behavior. Even gases and temperatures occupy areas which have location, size, depth, and form. It will be our problem in the present section to discuss briefly the behavior adjustments which the human subject can make to these aspects of the stimulating objects. In considering the classification of receptors we have already had occasion to comment upon certain aspects of the problem. Only the distance receptors for light, temperature, sound, and injury can serve to arouse behavior to objects not in contact with the organism. Of these receptors the eye is the most perfectly adapted to be affected by the spatial characteristics of objects. And light, the stimulus for the eye, is the only stimulus which, by being transmitted in a straight line, is suited to the determination of detailed behavior upon the basis of these spatial aspects. Among the contact receptors, those which are activated by stimuli in contact with the organism, only the tactual receptors are well adapted to the control of behavior on the basis of size, form, etc. Of the proprio-ceptors, those which lie in the vestibular portion of the inner ear and those which lie in the muscles are particularly affected by the movements of the organism. We have no certain data on the rôle of the intero-ceptors in the control of that behavior which we are now discussing.

Most of the experimental studies of spatially discriminative behavior have sought to determine the capacity of each receptor when examined in isolation from the other receptors. This is a highly important method of approach to the problem, but it ignores the fact that the spatial adjustments made by the organism in its normal life-activities are controlled by many receptors. The proprio-ceptors lying in the muscles are almost universally active in spatially determined behavior, as e.g., in locating sounds and contacts, in following moving objects, and in adjusting the eyes to distant objects.

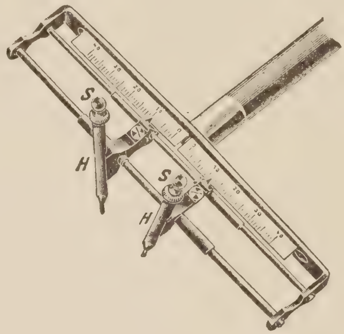

FIG. 62.—An aesthesiometer

In the present account the limitations of an elementary book require us to be content with a brief discussion of a few problems drawn from the discriminative behavior made to certain spatial characteristics in the fields of contact, vision, and audition.

Contact: The Localization of the Stimulus.—One of the fundamental problems in tactually controlled behavior is that of the localization of the stimulus (1) with reference to another tactual stimulus and (2) with reference to a visual stimulus. The first phase of the question may be stated as follows: If a given point on an individual's hand is touched while he is blindfolded, how accurately can he then touch the same spot; or how far apart must two compass points be before they cease to call forth the behavior made to one point alone? The second phase brings out much the same phenomena and is tested by having the subject indicate on a model of an arm the location touched. The whole question may be styled the problem of the *two-point threshold.* When the compass points are used, the apparatus is an aesthesiometer (Fig. 62), and the two points may be applied simultaneously. The procedure consists in applying the points quite widely separated at first and then closer and closer together until the subject reacts as he has

been trained to react to *one* contact stimulus. Then the experimenter starts with a separation a little less than this and gradually increases the distance of the pointers until the subject responds as to two contact stimuli. The two-point threshold is determined by averaging the values at which the subject first responds with "one" in the descending series and with "two" in the ascending series. Care must be taken that the compass points are poor conductors of heat (hard rubber points are usually used), or temperature stimuli enter to complicate the test.

Weber found that the threshold was least on the tip of the tongue and greatest in the middle of the back and on the upper arm and leg. A few of his measurements are here given:

	mm
Tip of tongue	1
Red of lips	5
Cheek	11
Back of first phalanx of finger	16
Back of hand	31
Middle of back	68

He also found that localization was more accurate on the arms and legs in a transverse than in a longitudinal direction. Furthermore, with successive stimulation the threshold is lower. Judd found that each pressure-spot could be distinguished unless the spots were so close that individual stimulation was impossible.

Audition: The Localization of the Stimulus.—Here again, in order to illustrate the topic, we are to deal with the question of accuracy of localization. Our discussion may be brief. The apparatus usually employed is termed a sound-cage and enables one to present a sound in any direction from the subject who is seated within it (see Fig. 63). The subject, whose eyes are shut, may be required to localize the stimulus either by pointing or by naming the location in degrees, e.g., 45° left. Localization is most accurate between the regions opposite each ear and the median plane of the body, but when a sound is given in this median plane it is difficult for the subject to say whether it comes from in front or from be-

hind. The sound waves in this case stimulate the two ears with practically equal intensities. In the part of space lying immediately about the axis running through the two ears sounds are accurately

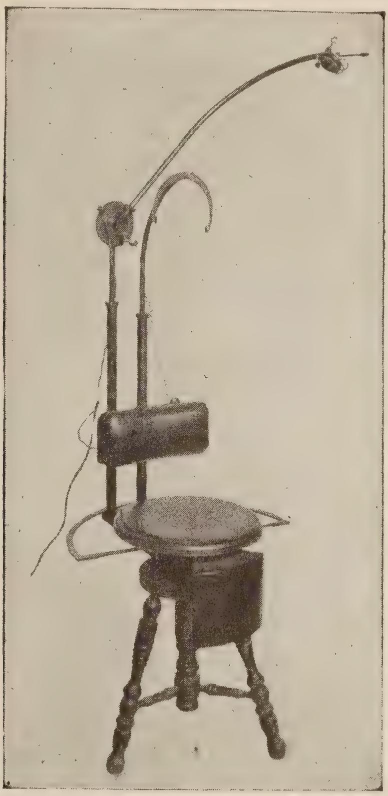

FIG. 63.—A sound-cage. The upright bar which carries an iron arc with a telephone receiver on it can be rotated about the subject seated on the stool. The telephone receiver can be varied in location anywhere in a sphere surrounding the subject's head.

localized as being on one side or the other of the body, but changes must be of several degrees before a change in the localization of the sounds calls forth a differential response.

As we have just suggested, the relative intensity of the sound to the two ears is a fundamental fact in its localization. Angell and Fite have shown, furthermore, that tonal complexity is an aid in sound localization, for pure tones cannot be accurately located. When the air waves conditioning a complex tone stimulate the two ears, however, the more distant ear fails to receive many of the partial vibrations due to the sound-shadow produced by the head. Such changes in the wave-form of the stimulus facilitate accurate space-discrimination. Other factors have also been proposed as aids in localization, but they cannot be discussed here.

Vision: Behavior to the Spatial Characteristics of the Stimuli.—Not only does the eye control the most accurate behavior with reference to the lateral characteristics of objects, but it is the only receptor which controls behavior of any particular accuracy with reference to the extension of objects in the third dimension. Inasmuch as man's environment is essentially a tri-dimensional one, it is extremely important that he be able to react accurately to it. A part of the sensory control of this behavior is dependent upon peculiarities of retinal stimulation. Much, however, depends upon kinaesthetic nervous impulses coming from the ciliary muscle and from the six extrinsic muscles of the eye, that is, upon impulses aroused by the responses of accommodation and convergence.

The chief visual characteristic which determines behavior to the tri-dimensional aspect of objects is that of the binocular disparity of retinal stimulation. (To the beginning reader this is a very difficult topic; but if he will study carefully the diagrams of Figure 64 and actually make the observations which we describe, he will be rewarded by a better understanding of one of the most important problems in human behavior.) Let us proceed to a discussion of binocular disparity and its rôle in the determination of behavior. If the eyes are fixated on point F, Figure 64-I, the point S is reacted to as though there were two points located respectively at S' and S''. S' results from stimulation of the left eye, and S'' results from stimulation of the right eye. Furthermore, S' is on the left and S'' is on the right. If the eyes are fixated on point F in No.

II of Figure 64, the point S is reacted to and located as though there were two objects, one at S' and one at S''. S' again is due to

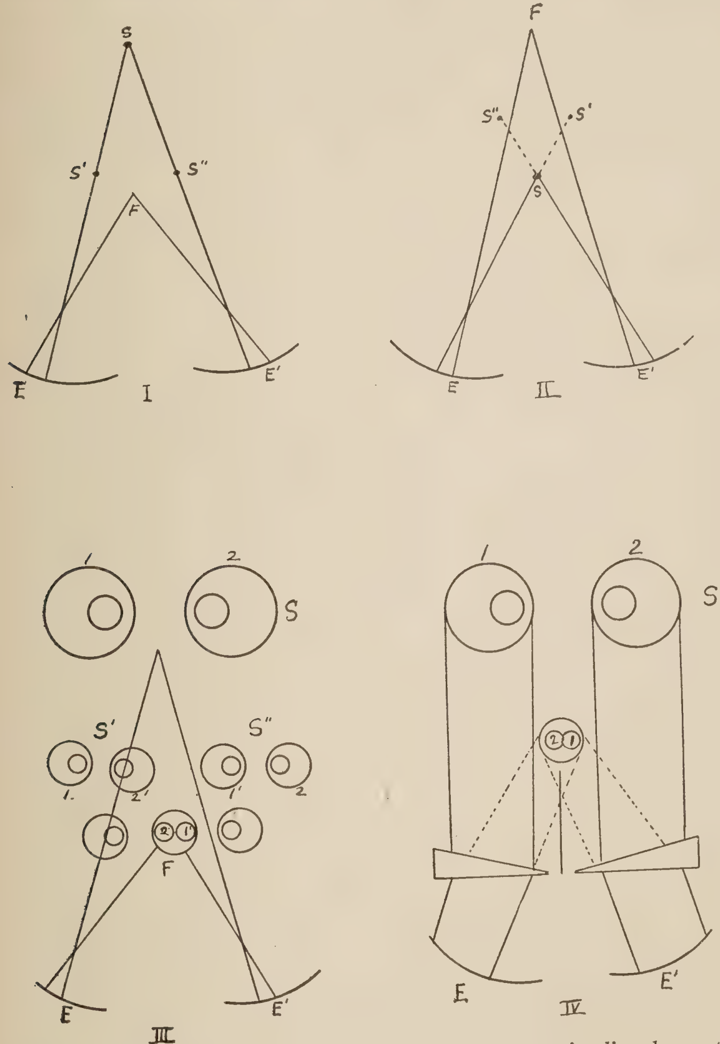

FIG. 64.—Diagrams of the relationships, between the stimuli and receptors, underlying responses to the tri-dimensionality of visual objects.

stimulation of the left eye; and S'' to stimulation of the right eye. However, they are now reversed, S' being on the right and S'' on the left. These statements can easily be verified by using two fingers, or two pins, for points F and S, and by closing first one eye and then the other in order to determine which eye is responsible for S' and S''. *We may conclude from this that any visual object located beyond the fixation point will be reacted to by the trained observer under laboratory conditions, as though doubled but not reversed. Any object located nearer the subject than the fixation point will be reacted to as though doubled and reversed. The fixation point is always reacted to as a single stimulus object.* The ordinary subject in everyday life does not behave as we have indicated. He merely behaves as though S were farther or nearer than F, as it is. *The hypothesis, therefore, immediately presents itself that the behavior of the normal subject with reference to location in depth is controlled by the before-described peculiarities of retinal stimulation, called retinal disparity.* Light from F always falls upon the two foveas, but light from S sometimes falls on the two nasal halves of the eyes and sometimes on the two temporal halves. In the former case S is localized beyond F; and in the latter case, nearer.

We can proceed to test this matter further with No. III of Figure 64. Draw, as a substitute for the point S, two pictures of a cone with the smaller end nearer than the larger end. Let the picture on the right (2) be the view as seen by the right eye with the left eye closed, and the picture on the left (1) be the view as seen by the left eye with the right eye closed. The larger circles at S will be identical. The smaller circles will occupy different positions in the larger ones. The distance between the centers of the two large circles should be the subject's interpupillary distance. Now have the subject hold the card on which the figures have been drawn in front of his eyes, both open, and fixate a point F. The trained subject will now behave as though stimulated by S' and S''. If he varies the distance from S to F until the larger circles of 1′ and 2′ overlap and then coincide, as at F, he will now behave not as though stimulated by a plane figure but as though stimulated by a large circle

and a smaller one which is located beyond the large circle. In other words, the subject now responds as to an object having three dimensions. Why is the smaller circle located farther than the larger one? In *S*, and also in *F*, which is the theoretical construction of what results when 2′ and 1′ are placed one upon the other, light from small circle 2 falls on the nasal half of the left retina. Light from small circle 1 falls on the nasal half of the right retina and continues to do so at *F*. This is the condition described in No. 1 of the figure as necessary for the subject to locate one point (here the smaller circle) as farther than the fixation point.

Before passing to the consideration of No. IV of our figure, let us raise another question: Why should objects be located farther than the fixation point when their rays of light fall upon the two nasal halves of the retinas? This seems to be due to the fact that the eyes must diverge from *F* to *S* in order to fixate *S*. This divergence brings with it different muscular actions and therefore different kinaesthetic and tactual stimuli. These movements in the past history of the organism have been conditioned to different hand responses of reaching and to different walking responses than the hand and leg responses with which increased convergent movements of the eyes have been conditioned. The results of this past training modify the behavior of the subject although the actual eye-movements do not take place in the present instance.

Now let us comment upon No. IV of the figure. The diagram represents the mechanics of the common stereoscope illustrated in Figure 65. Light from *S* passes through the refracting prisms, one-half to each eye, and is bent so that the subject reacts to a superposition of 1 and 2. The smaller circles now fall upon the temporal halves of the two retinas and are reversed as in No. II of the figure. They are, therefore, reacted to as though located nearer than the larger circles which, now being single, serve as the fixation point does in other illustrations.

We have gone at such length into the discussion of retinal disparity and its related muscular adjustments because of its interest to the student of human behavior. There are other aspects of the

stimulus which help to condition behavior to the tri-dimensionality of objects, and these should be mentioned. The interposition of one object between the eye and another object results in the former object being located nearer than the latter. Hazy objects are usually located farther than distant objects. The relative sizes of objects also helps to determine which will be located farther away. Thus, if the retinal image from a man is smaller than that from a cat, the man is located farther away. All of these sensory cues seem to determine the behavior involved in localizing as a result of the past training of the subject.

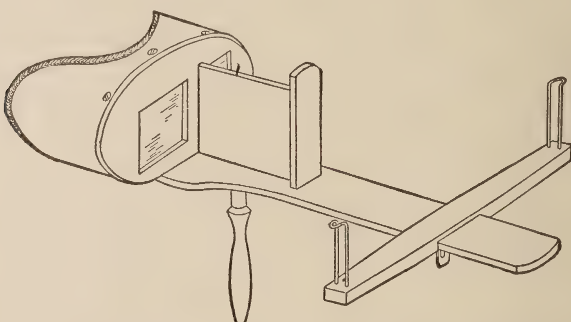

FIG. 65.—A common form of the refracting stereoscope

Self-Stimulation of Receptors.—The difference between receptors with reference to their stimulation by the organism's own activity is so marked and the consequences so fundamental for environmental adjustment that special attention must be invited to the problem.

The normal human subject does by muscular movement stimulate receptors lying in the muscles, joints, and tendons, thereby starting kinaesthetic (and often cutaneous) neural impulses. These impulses may come from the arms, the legs, the body-trunk, the vocal muscles, or from any other place where muscles are found. Certain of these muscular responses produce sound waves in the air which, stimulating the ear, give rise to auditorily controlled behavior. Some muscular responses also change the equilibrium of

the body and so affect the receptors concerned with maintaining bodily equilibrium. Receptors for organic sensitivity, particularly those involved in instinct, may also be stimulated through the muscular and glandular activity of the subject. Taste, smell, and vision stand out as a group of receptors for which the human organism's own activity furnishes no important stimuli. Taste offers no exceptions. The sense of smell can be aroused by odors produced by the organism. The human individual does not, however, produce light, and its activity in directly arousing visual processes is therefore limited to the insignificant cases of blows on the head and pressures on the eyeball.

The importance of these differences in accessibility to self-stimulation lies here: The organism may become self-dependent in its stimulations and in the resulting behavior just to the extent that it can produce with its own activity the stimuli necessary to excite its own receptors. By being independent to this extent of its environment, the organism possesses one of the fundamental requirements for thinking. The present chapter is not the place to elaborate this point. It is sufficient to indicate the fact that the activity of the vocal muscles and the resulting kinaesthetic and auditory stimuli are of prime importance in language and thought. The organism's control over these processes is acquired through training.

REFERENCES

Baird, J. W. "The Color Sensitivity of the Peripheral Retina," *Carnegie Institution of Washington Pub. No. 29* (1905).

Bingham, W. V. "Studies in Melody," *Psych. Rev. Mon.*, XII (1909), No. 50.

Cunningham's *Textbook of Anatomy* (4th ed., New York, 1915).

Dunlap, K. *Elements of Scientific Psychology* (St. Louis, 1922).

Hardesty, I. "On the Nature of the Tectorial Membrane and Its Probable Rôle in the Anatomy of Hearing," *Amer. Jour. Anat.*, VIII (1908), 109–79.

———. "A Model to Illustrate the Probable Action of the Tectorial Membrane," *Amer. Jour. Anat.*, XVIII (1915), 471–514.

Helmholtz, H. von. *Sensations of Tone.* Trans. by Ellis (London, 1885).

———. *Treatise on Physiological Optics.* 3 vols. (Ithaca, New York, 1924–25).

Ladd, G. T., and Woodworth, R. S. *Elements of Physiological Psychology* (New York, 1911).

Le Conte, J. L. *Sight* (London, 1883).

Moore, H. T. "Genetic Aspect of Consonance and Dissonance," *Psych. Rev. Mon.,* XVII (1914), No. 73.

Parsons, J. H. *An Introduction to the Study of Color Vision* (Cambridge, 1915).

———. *An Introduction to the Theory of Perception* (New York, 1927).

Peterson, J. "Combination Tones and Other Related Auditory Phenomena," *Psych. Rev. Mon.,* IX (1908), No. 39.

Pierce, A. H. *Studies in Auditory and Visual Space Perception* (New York, 1901).

Rand, Gertrude. "The Factors That Influence the Sensitivity of the Retina to Color," *Psych. Rev. Mon.,* XV (1913), No. 62.

Shambaugh, G. E. "A Restudy of the Minute Anatomy of Structures in the Cochlea with Conclusions Bearing on the Solution of the Problem of Tone Perception," *Amer. Jour. Anat.,* VII (1907), 245–58.

Titchener, E. B. *Textbook of Psychology* (New York, 1910).

Watt, Henry J. *The Psychology of Sound* (Cambridge, 1917).

CHAPTER VI

HABIT

Introduction.—Practically all responses made by the human subject can be modified by training. Indeed, it is in the great complexity of his learned responses that man differs most from the infrahuman animals. In the discussions of the conditioned reflex and the modifications of instinct, we have already had something to say concerning habit-formation. In the present chapter, it is our purpose to examine this latter topic in more detail in order that we may better understand the various factors which influence the acquisition, retention, and use of habits.

A habit is an acquired specific form of verbal or non-verbal response such as writing, reading, running the maze, or piano playing. In each case the response is aroused only when some stimulus or combination of stimuli acts upon the receptors. Each acquired response is a co-ordination of inherited and acquired forms of response. This co-ordination may involve many reflexes and many habits, or it may involve but one reflex and only a modicum of habit. The latter case is well illustrated in the typical conditioned reflex. Thus, prior to training, the pupil of the eye contracts when the retina is stimulated with an increased intensity of light. After suitable training, the same response will be made to an auditory stimulus which prior to the training had caused a dilatation of the pupil. Training has resulted in substituting a new stimulus for the response of contraction and a new response for the auditory stimulus (see p. 48). With such a complex co-ordination as running the maze, many reflexes and previously established habits are integrated into a specific response.

We have spoken of habit as an acquired co-ordination of reflexes just as we described instinct as an inherited co-ordination of such responses. Underlying and conditioning habit there must be

an acquired connection of nervous processes. Ordinarily, when we think of habits, we tend to think of movements of the hands and feet, as in writing and dancing, but speech is also a habit, and the same principles apply to both instances of habit formation. To connect one verbal response (cat) with another (dog) is as much a case of habit formation as the connection of different steps in a dance. When two or more trials, i.e., two or more presentations of the stimulus, are necessary before the connection can be made, what is learned in the early trials must be retained in order that learning may be completed. Since retention, therefore, is as necessary to the parts of a habit as to the completed form of the response, our study of retention consequently covers the learning process and the process of forgetting.

Most of the experimental work upon habit has been done upon verbal responses using two general types of procedure: studies of associating verbal responses through the use of such stimuli as poetry, nonsense syllables,[1] and prose; and studies of vocal-verbal and manual-verbal responses to indicate other sensory material employed (odors, tones, etc.). Some work has been done upon nonverbal habits. Here the investigations have concerned the question of the acquisition of skill in typewriting, telegraphy, shooting, mirror drawing, running the maze, etc. Both classes of problems concern true habits. Both are in equal degree acquisitions of skill.

Evidences of Retention.—Each habitual response is a result of training during a period of learning, or acquisition. Once established, the stimulus response co-ordination is retained for a greater or lesser period of time. When we say that the co-ordination is retained, we mean one or all of three very concrete things: (1) The response can be aroused, or reinstated, by a presentation of the stimulus. Thus a subject who has learned to run a maze or to re-

[1] Nonsense syllables were first devised by Ebbinghaus (1885), the pioneer student of the acquisition and retention of verbal response co-ordinations, whose contribution we shall study under retention. They are constructed of two consonants with a vowel between. The syllable so constructed must not be a conventional word and it must suggest an actual word as little as possible. Examples are: **rik, rih, lan, sul, ruc, bez.**

peat the French equivalents of a list of English words may still be able to respond correctly to the respective stimuli after an interval of one week during which there has been no practice. (2) Although the subject may no longer be able to make the response to the stimulus as he has been trained to do, he may still be able to designate which stimuli he has been trained with and which stimuli he has not been trained with. In other words, he behaves differently to the maze or to the words on which he has been trained than he does to mazes or words on which he has not been trained. (3) Although the subject may no longer be able to make the response which he has been trained to make to the stimulus, and although he may react no differently to this stimulus, e.g., the list of English words, than to other comparable stimuli, e.g., other lists of English words, nevertheless his organism may still retain traces of the results of previous training. We can establish this fact by having the subject relearn the original stimulus-response co-ordination. If we compare the amount of time required for the original learning with the time required for the relearning, we shall find, if there is any retention, that the relearning requires less time than did the original learning.

The Methods of Studying Retention.—The three conditions of behavior which constitute the evidence for the retention of stimulus-response co-ordinations also suggest the methods by which retention can be experimentally studied. The first method is that of recall or *reinstatement*. This method is used in all studies which involve recitation or other form of recall of the specific co-ordination under investigation. A specific form of this method is that of *paired associates,* devised by Calkins and perfected by Mueller and Pilzecker. In this form of the method the material to be used as stimuli is presented in pairs (of words, pictures, etc.). The subject is instructed to speak the words, e.g., and the entire series of paired stimuli are presented serially a specified number of times. Then the first members of the pairs are presented to the subject in a changed order. He is now instructed to recall, i.e., to reinstate, the response formerly aroused by the second member of the pair. Retention is measured by the length of time that it takes him to reinstate the

required response and by the proportion of right to wrong responses. Thus the series *a-b, c-d, e-f, g-h* is presented to the subject one pair at a time, each pair for one second. After the fifth reading, let us say, the subject is then shown *c,g,a,* and *e,* and instructed to reinstate the responses (*d,h,b,f*) which had formerly been given to the absent stimulus of the pair.

The second method of studying retention is usually called the method of recognition. This method requires the subject to discriminate between old and new stimuli, i.e., between stimuli with which the subject has been trained and stimuli with which he has not been trained. We shall therefore call this second method *the age of stimulus method.* A typical procedure in the use of this method is as follows: (1) Colors, grays, odors, tones, pictures, advertisements, words, whatever it be, the stimuli for the experiment are chosen. (2) This selected material is now presented to the subject either serially or in pairs. During the presentation the subject is instructed to respond with the verbal response which he has learned to call the name of the stimulus, or he is permitted to make no overt response. (3) The stimuli may be presented any number of times up to the point where the subject can reinstate all of the responses which he has learned for the series. And (4) at the end of any presentation the stimuli may be presented to the subject in the same arrangement in which they were given originally or in a different one, but in either case new stimuli will be mixed in with the old. The subject is now instructed to make one type of response to the old stimuli and another to the new. This discriminative test need not be given immediately after training. It may be deferred for any length of time chosen by the experimenter.

The third method of studying retention is *the saving method* of Ebbinghaus. In this method we record the number of trials, the amount of time, and the number of errors in the learning process for any given stimulus-response co-ordination. Later, after the lapse of a certain length of time, the subject again learns the co-ordination up to the same level of skill required in the original learning. The difference between the records for the original learn-

ing and the same measurements for the relearning is an indication of the amount of retention. If a subject requires as much time for the second learning as for the original learning, there is no evidence that he has retained any of the initial practice effects.

Conditions Favorable to Learning.—Experiment has shown that the following factors hasten learning: the absence of fatigue,

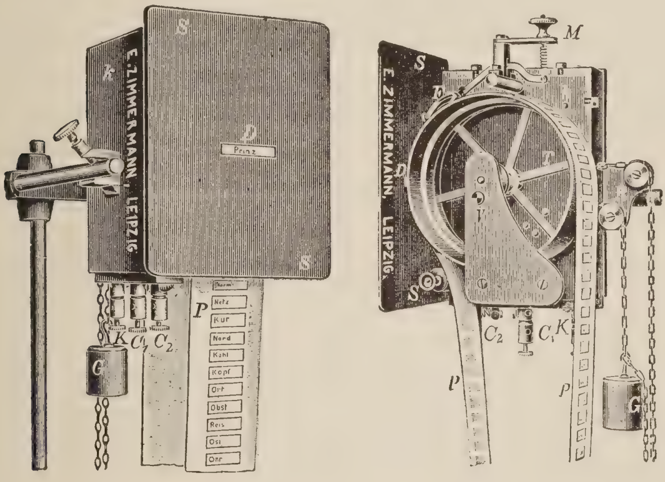

FIG. 66.—Wirth's memory apparatus. This apparatus makes possible the serial presentation of material to be learned. The exposure time can be accurately controlled.

the dominance of the chosen stimuli, variations in accentuation, an optimum rate of presentation of stimuli, the possibility of incorporating old habits in the new so that less real learning is necessary, practice, distributed effort, the use of the whole as opposed to the part method of presenting the stimuli, the absence of interfering habits, and normal physiological conditions in the subject. Since it is inexpedient to present here the data which go to substantiate all of these statements, comment will be made only upon a few. In each case, however, the reader will do well to plan an experiment suited

to the investigation of the influence of each factor upon habit-formation.

Behavior Records of Habit Formation.—In considering the influence which any factor may exercise upon habit it is necessary to have before us the aspects of behavior which are recorded in studies of habitual responses. These aspects are as follows: (1) the time required to make each response (trial) and the total time required for all the responses preceding the final formation of the co-ordination; (2) the number of errors or the number of correct responses; (3) the total number of trials (presentations of the stimulus) required for learning; (4) the form of the curve which represents the progress of learning in terms of time and accuracy; (5) the speed and accuracy of the reinstatement (recall) of the habit after various periods of time during which there has been no practice of this habit; (6) the speed and accuracy of discrimination between old and new stimuli; and (7) variations in the first four aspects of behavior under the conditions of relearning present in the saving method of Ebbinghaus.

Experimental Studies by the Age of Stimulus Method.—The age of stimulus method may be used to examine all of the problems growing out of the influence of specified factors, such as drugs, fatigue, and amount of practice, upon the retention of stimulus-response co-ordinations. With this understanding we shall comment briefly upon several problems in which the method has been used. (1) The relative accuracies of the methods of reinstatement and age of stimulus. The general result here has been to demonstrate that although many stimuli upon which the subject has been trained will no longer arouse the old responses, the subject may still be able to discriminate between the old stimuli and new ones. Thus the response of repeating a stanza of poetry when stimulated by the words, "repeat this," may be impossible, and yet the subject may be able to pick out the correct stanza from a group of other stanzas. This greater sensitivity of the age of stimulus method is also revealed when we compare the amount of work necessary to enable the subject to reinstate a response with the amount of work

necessary to enable him to discriminate between old and new stimuli. This is well shown in an experiment by Mulhall (1915). Mulhall's subjects required an average of 4.76 trials before they could reinstate the responses called for by a list of fifteen words. However, after an average of 2.64 trials the subjects were able to distinguish between the fifteen old words and fifteen new words which were interspersed with them. When the material used was nonsense syllables, an average of 7.12 trials was required for reinstatement, i.e., for recitation, and an average of 5.80 trials was required for the discrimination between old and new stimuli. (2) A second problem studied concerns the relative ease with which old and new stimuli may be discriminated when the responses involved are conventional words as opposed to nonsense syllables. Conventional words, such as cat, dog, island, and river, are stimuli which call forth definite verbal responses in the subject in virtue of extensive past training in the English language. These stimulus-response coordinations are already well established at the time of the experiment. The new task which the subject confronts is the integration of the series. The situation is quite different with nonsense syllables. Here there are no established responses to the stimuli which are new in the subject's history. The task of mastery of the series is therefore much more difficult than is the case with conventional word stimuli, inasmuch as the subject must not only learn specific responses to each of the syllable stimuli but must also integrate the stimuli as a whole. Mulhall's experiment, which was referred to before, shows very clearly that the discrimination of old and new stimuli is easier when the experiment concerns words than when it concerns nonsense syllables. (3) The third problem to be considered is the problem of the loss in ability to discriminate between old and new stimuli. The rate at which such a loss proceeds varies greatly with the amount of practice which the subject has had with the type of response tested. Thus the loss proceeds most rapidly where nonsense responses are involved and least rapidly with highly standardized responses. The Strongs (1916) made an investigation of the accuracy with which subjects could pick out twenty old word stim-

uli from a group containing these stimuli and twenty new word stimuli after four different intervals of time during which there was no training. After 5 minutes 86 per cent of the old stimuli could be discriminated from the new; after 1 day, 46 per cent; after 2 days, 33 per cent; and after 4 days, 30 per cent.

An Experiment by the Saving Method.—We have already seen the relatively great amount of work necessary to discriminate between old and new stimuli when one series of stimuli is unrepresented in the subject's past history, as is the case with nonsense

TABLE VI

Period since Learning Was Completed	Percentage of Saving, Nonsense Material	Percentage of Saving, Poetry
5 minutes	98	100
20 minutes	89	96
1 hour	71	78
8 hours	47	58
24 hours	68	79
2 days	61	67
6 days	49	42
14 days	41	30
30 days	20	24
120 days	3	....

stimuli, and when the other series of stimuli is well represented, as in the case with conventional word stimuli. A similar situation exists when the method of investigation is that of saving method. In an experiment by Radossawljewitsch the subjects were trained to repeat poetry and nonsense material. When various intervals of time had elapsed after the completion of the learning, the subjects were again trained to the point of mastery. The percentages of saving for the different periods of time were as shown in Table VI. We have already pointed out that the reason for the advantages possessed by conventional stimuli lies in the great amount of previous training which the subject has had with these stimuli. This training has resulted not only in establishing specific stimulus-response coordinations for each word stimulus, but it has resulted in those more

complex co-ordinations which group word responses together in phrases, sentences, and topics. These effects of previous training cannot fail greatly to influence the results of any subsequent testing of the behavior concerned.

Remote Associations.—The previous training which lies at the basis of conventional stimulus-response co-ordinations has resulted in the establishment of simple and complex types of behavior as already described. Not only, however, are co-ordinations established between adjacent responses, as in phrases, but they are further found between remote components of the stimulus-response series. The clearest cases in non-language habits are instances of the actual elimination of certain intermediate responses—usually referred to as the elimination of random movements. Thus a rat in learning to run a maze (1) runs slowly along the true pathway, (2) turns into a cul-de-sac, (3) turns and runs out, and then (4) continues along the true pathway. In practically every case the animal finally learns to associate 1 and 4, eliminating 2 and 3. The omission of the cul-de-sac may first occur accidentally and then be repeated as a result of inhibition by organic processes until recency and frequency finally complete the learning. Another type of remote association may also be cited, food, e.g., secured at the *end* of the maze soon furnishes the animal a stimulus for vigorous and efficient efforts at the beginning of the maze where at first only curiosity and random wandering were manifested.

Experiments upon verbal habits, using nonsense syllables as the stimuli, have made possible a more detailed understanding of these remote associations. Ebbinghaus tested the matter in the following manner: He constructed six series of sixteen nonsense syllables each, which the subject repeated until he could reproduce them without error. Twenty-four hours later the syllables composing each series were rearranged and then relearned, the rearrangements consisting in placing side by side syllables that had originally been separated by 1, 2, 3, or 7 intervening syllables, and also a series where the first and last syllables were retained in place and the others rearranged by chance (referred to in Table II as "permutation

of syllables"). When these rearranged series were learned after the twenty-four-hour period, the amount of time saved in the relearning was an indication of the amount of association between the remote pairs. Table VII, taken from Ebbinghaus,[2] indicates the results. From this it is apparent that the strength of the association between remote pairs is dependent upon the extent of their remoteness. The far-reaching effects of association shown by this test serve to hold muscular responses together in a thoroughgoing unity.

TABLE VII

Number of the Intermediate Syllables Skipped in the Formation of the Derived Series	Time for Learning the Original Series (Seconds)	Time for Learning the Derived Series (Seconds)	Saving of Work in Learning the Derived Series (Seconds)	Probable Error of Saving of Work (Seconds)	Saving of Work in Percentage of Original Learning Time
0	(1,266)	(844)	(422)	....	(33.3)
1	1,275	1,138	137	±16	10.8
2	1,260	1,171	89	±18	7.0
3	1,260	1,186	73	±13	5.8
7	1,268	1,227	42	± 7	3.3
Permutation of syllables	1,261	1,255	6	±13	0.5

In the following sections on "Habit-Interference" and "Transfer of Training" we shall see in detail other ways in which habits interact.

Habit Interference.—It is a matter of common knowledge that many habits interfere with the formation of new ones. If I have a habit of securing a book from a certain shelf it is difficult to shift and begin taking it from another. Long-established habits of all kinds are hard to change, presumably because the modes of neural activity which condition them are hard to change. Early in the experimental study of memory it was shown that if the responses to a series of nonsense syllables, *A*, were associated with those to another series, *B*, the association of *A* with a new series, *C*, would be impeded or interfered with. This agrees with the familiar

[2] H. Ebbinghaus, *Memory,* p. 106, trans. by Ruger and Bussenius (New York, 1913).

observation that if two names are equally often employed, one is frequently unable to recall either when occasion arises.

There is an additional type of interference in language habits that is worthy of notice, the phenomenon of *retroactive inhibition.* Associations in the nervous system require a certain interval of time in which to "set," and if this interval is not forthcoming because of the too early onset of new associations, the first ones are retroactively inhibited. Students taking lectures meet this phenomenon constantly. The professor makes a point, but before the point can be assimilated another is brought forward and insistently emphasized, with the result that the former is forgotten.

The following schema is helpful in attempting to grasp the essential experimental conditions under which habit interference, habit transfer, and retroactive inhibition are studied:

RETROACTIVE INHIBITION

Experimental Group of Subjects	Control Group of Subjects
Training on habit A	Training on habit A
Interpolated work	Interpolated rest
Retraining or retesting of A	Retraining or retesting of A

HABIT TRANSFER AND HABIT INTERFERENCE

Experimental Group of Subjects	Control Group of Subjects
Training on habit A	Rest
Training on habit B	Training on habit B

From this schema we can see that the problem in retroactive inhibition is the influence which the learning of a given habit (referred to before as interpolated work) will have upon the retention of previously learned habits, whereas the problem in interference and transfer is the influence which the learning of a given habit will have upon the subsequent learning of other habits. In each case a control group of subjects having equal ability is necessary.

Transfer of Training.—Interference is the negative side of habit interactions, while transfer is the positive side. Does training upon one topic aid in the mastery of others? Is there, for example, any reason to believe that the acquisition of habits in mathematics

will aid in the acquisition of habits in physics? To what extent can one have a formal discipline that is valuable irrespective of the content of the habits to be acquired? *Transfer does occur on a large scale.* Habits that have been acquired thus aid in the acquisition of new ones—in fact that is the only manner in which new habits can be built up. The aid is not, however, the training of some faculty or capacity. One habit aids another to the extent that the two involve common elements. These common elements may be an inclusion of part of one habit in the next, e.g., the same nonsense syllables may occur in two series, or mathematical formulas may be present in physics as well as in mathematics. Experiments that rule out such an overlapping and that still show positive evidences of transfer are to be explained on the basis of common elements of the following type: improved methods of study, increased resourcefulness, and the application of economical methods of learning.

We may illustrate this in terms of cross-education as revealed by Starch's data on mirror-drawing. In this experiment an apparatus similar to that shown in Figure 67 is used. The subject looks into the mirror, his hand screened from direct view, and seeks to draw with his pencil a line midway between the two boundaries of the star. The time required for each tracing is measured in seconds. Starch had each of ten subjects make (*a*) one-half of a complete tracing with the left hand, (*b*) ten complete tracings with the right hand, and (*c*) another one-half tracing with the left hand. During practice *b*, the right hand improved on the average 53 per cent. This training resulted in an average improvement of *c* over *a* of 49 per cent, although the left hand was not practiced during the interval *b*. An undetermined part of this improvement may be due merely to the fact that the improved record in *c* was caused by the practice in *a*, and not by the training in *b*. Ewert's experiment was devised as a check on this possibility. Two groups of subjects were chosen having the same average behavior test score. One group was given one trial with the left hand, then fifty trials with the right hand, and finally one trial more with the left hand. The other group was given two trials with the left hand, but with a rest of one hour

between tests. For the first group, the left hand in its second trial was 82 per cent better than on its first trial. For the second group the left hand in its second trial was 46 per cent better than on its first trial. Approximately 36 per cent of the gain made by the left hand in the first group may, therefore, be explained by the training which the right hand received.

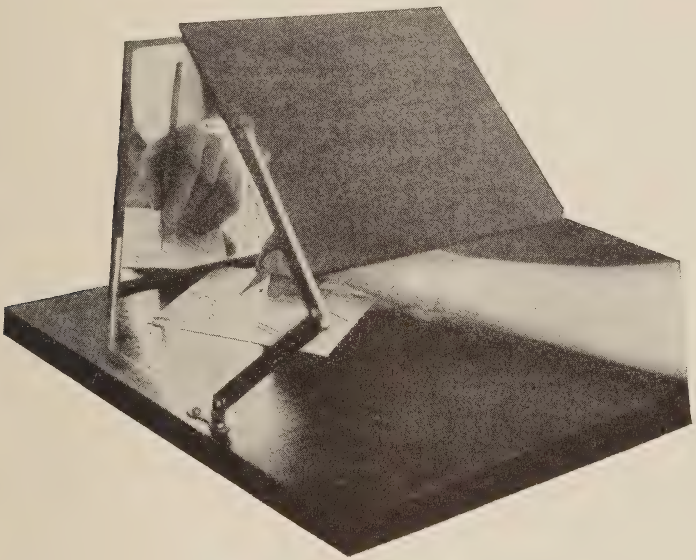

Fig. 67.—The mirror-drawing apparatus

Effects of Practice and of the Instruction Stimulus.—These two important conditions affecting the degree of retention are grouped together solely for the convenience of brief discussion. Individuals who practice the acquisition of any type of task improve their retentive capacity markedly. This improvement, which may occur in learning to respond to nonsense syllables, poetry, scientific formulas, or other material, is to be explained as a particular instance of transfer where improved methods of learning are utilized. As a striking instance of practice effect we may give the case of

Dr. Rueckle, a mathematical prodigy tested by G. E. Mueller (1913). After six years' practice on the stage he could learn to repeat 204 digits in less than 9 minutes. Prior to this time it had required 18 minutes. His ability to learn colors, syllables, etc., however, had decreased, a condition that was undoubtedly due to the intereference with his new habit of learning.

In Part II, chapter iv, we have already learned of the general influence which instruction stimuli exert upon behavior. In the present context it is important to note the influence of instructions upon learning and retention. During the learning process itself, instructions serve to confine the subject's efforts to the problem before him. During retention, also, instructions given by the experimenter serve to direct behavior. In addition to these effects experiment has shown that retention is better if the subject instructs himself to work for good retention. This factor of instruction accounts for a large part of the difference between the stimulus-response coordinations which are incidently set up during the individual's lifetime and those which are set up as a result of specific training. Stimuli are constantly being presented to the subject, who as constantly makes responses based upon certain of the aspects of the stimuli. He responds, e.g., to the figures on the face of a watch and to the designs on stamps; but at a later date it is impossible for him to say what kind of figures were on the watch and what the designs were which the stamps bore. If the subject is to make such responses he must be trained to make them. One way by which he can be trained is to instruct him to respond to the aspects of the stimulus in question. Not only is this necessary, but it is also desirable, if he is to make the best record when tested for retention, that he be instructed concerning the nature of the retention test which is to be made later. If the method of paired associates is to be used, the subject will adopt modes of procedure which he would not use were the savings method to be the one employed. Students often meet this difficulty when they attempt to master certain material without having been told the exact method by which they are to be examined. Furthermore, responses learned by "cramming" for

examination are usually lost early, for although the instruction is for retention, still it is for temporary and not for permanent retention. The ability to acquire a large number of responses for a temporary use is of great value to lawyers, teachers, and individuals in many professions who meet situations of this type constantly. It is wise, after all, that most of the responses which we learn should be soon forgotten!

In experimental procedures the subject is ordinarily instructed not to reinstate the recently learned behavior in the interval between the experimental sittings. In everyday life, however, repetitions are constantly made in the intervals between periods of study. This practice has both its advantages and disadvantages. Errors are prone to creep into these attempted reinstatements, and so are sure to be incorporated into the behavior which is being acquired. Aside from his, however, Witasek (1907) and Gates (1917) have shown that the active reinstatement required in these attempts to recite is more advantageous in promoting learning than the more passive reinstatement of the continued reading of the passage to be learned.

The Whole versus the Part Method.—In our discussion of repetition the question at once arises concerning the method to be used in any problem of learning. When the average subject sets about learning a given amount of material he usually divides this material into small units and masters the task one unit at a time. He learns section by section in a behavior textbook, or one stanza of a poem after another. It was shown by Lottie Steffens (1900), however, that learning by *parts* is less efficient than learning the material as a whole, i.e., reading over the entire task each time. This rule is even more applicable to material that has already been partially mastered, conventional word stimuli, than to nonsense material. The gain comes, according to Meumann, largely in the fewer number of repetitions required and in the better retention. The whole method owes its advantages to the following facts: (1) it aids a uniformly distributed and sustained effort; (2) with connected word stimuli, reading through the entire material is the best way

to insure that relevant old habits will be aroused by the stimuli; (3) part learning not only requires that each part (stanza, for example) be learned, but in addition special learning must be used to join the parts together; and (4) part learning produces many faulty habits. If we use stanzas of poetry as the illustration, part learning connects the concluding responses of each stanza with the beginning responses of the same stanza and not with the beginning responses of the following one. The whole method is disadvantageous, however, when the material is so long that the work involved in learning is very fatiguing and when the process of learning is so slow as to cause the subject to work less vigorously.

Furthermore, when the material is of very uneven difficulty, the method is bad to the extent that it requires as many repetitions of the easy as of the difficult sections. In such cases it is best to underscore or otherwise mark the difficult passages so that extra work may be concentrated upon them while the part already mastered may be skimmed easily and rapidly. As yet insufficient experimentation has been done to warrant an extension of the law to other than verbal habits, although work by Pechstein on rats and human subjects in the maze indicates its presence there.

Distribution of Work.—What variation is secured in the learning process by giving the trials far apart as opposed to close together? What effect does it have upon the economy of learning to distribute one's work through a long period of time? The more the work is distributed in time the less the number of trials required for mastery, and vice versa, the more the work is confined to a short period of time the greater the number of trials necessary for mastery. If fifty lines of poetry, for example, are read over once a day, or once every other day, fewer repetitions will be required to learn them than if they were read over two, three, or more times daily. It must be noticed, however, that distributed learning extends over a longer period of time than does concentrated learning. One method is economical in extent of time required; the other effects a saving in the number of trials. This is true not only for verbal habits, as we have just outlined, but it is also true for other

habits. Ulrich and Warden, as we saw on page 61, have demonstrated it for learning in the case of the white rat, and Lashley has shown it to hold for men in learning to shoot with the crossbow. The rule, it seems, however, is more applicable to large than to small masses of material.

The explanation of the efficiency of distributed work lies partly in the fact stressed under retroactive inhibition. We may recall that it takes a certain interval of time for an association to "set" after it has once been made. If a second habit is begun too soon it interferes with the retention of the first. Distribution of work permits this setting of synapses to continue uninterruptedly.

Training and Economy in Methods of Learning.—The importance of a consideration of the foregoing principles of learning lies in the fact that *a trained capacity for the acquisition of habits implies a training in economical acquisition.* Whether or not a given method of habit formation is economical depends largely upon the reason for which the habit is to be formed: if one is not to retain for a long time, the instructions will be in accordance with that goal; and if one is to economize the *extent of time* devoted to a task, he will concentrate, not distribute, his work. It often happens that the ability to repeat a given material from beginning to end is not the important thing, but rather this is the ability to reproduce isolated responses (parts). In such instances the part method is undoubtedly more economical than the whole method. Consequently one must vary his methods constantly to suit changes in the goal to be attained. To conclude the matter we may say that the chief secret of a highly trained capacity for habit formation is the ability, first, to formulate specifically the end to be accomplished; second, to concentrate work upon the successive trials (repetitions); and third, to suit the method used to the goal to be attained. The greater apparent economy of adult memory is due to an increased breadth and complexity of past training, i.e., it lies in the increased behavior equipment that makes the utilization of these three points possible in a high degree.

Nature of Forgetting.—So far we have discussed retention from the positive side, that is, from the point of view of learning. When we have described the formation of various habits we have spoken only of the individual co-ordinations that have persisted from moment to moment and so *have entered into the constitution of the final perfected habit.* At each repetition of the material that is to be worked up into a habit errors occur until the last stage of completed learning is attained. If the individual is learning to repeat nonsense syllables he mispronounces and fails to recall properly, or he may even give responses not called for by the list, that is, his vocal muscles make wrong movements. If he is learning to typewrite or to run a maze he is continually making wrong movements with his hands or feet. When, however, learning is completed, these erroneous responses have been eliminated, i.e., they are forgotten so far as that particular habit is concerned. This fact that all responses which are not at the moment included in the present and ongoing habit are "forgotten," temporarily eliminated, is the fundamental nature of all forgetting. Accordingly, as I write these lines, habits of eating and talking are eliminated, though later they may be reinstated or recalled.

In a coming section on "The Fixation of Arcs in Habit," we shall inquire into the detailed causes for the elimination of the erroneous responses during habit formation. Our last few sentences, however, pointed out another and secondary form of forgetting. I am not now at the present moment in any real process of habit formation. I am actually engaged in a habitual response, writing, i.e., I am now reinstating this retained possible response. But there are very many other retained traces in my nervous system conditioning other possible habitual responses in which I might now be engaged. Why are not these habitual responses now reinstated, or, to put the matter the other way around, why are they eliminated at the present moment and forgotten? Why are certain nervous processes and not others active at this moment? The question of forgetting consequently presents itself in two forms: (1) At the time the neural associations underlying habits and instincts are formed, why are

certain neural associations excluded? This is the primary and fundamental question. (2) Why at any one moment are many neural associations passed by and not aroused to activity? Why are they eliminated from the activity of the present moment?

We shall discuss the former of these questions under the heading of "The Fixation of Arcs in Habit." Our comment on the latter question is as follows: A given form of behavior is absent (forgotten) at the present moment either because of the absence of the proper stimulus, because of the interference of other habits or neural processes, or by virtue of disuse which has rendered reinstatement difficult. This last factor we must now discuss at greater length.

Rate of Forgetting.—In what way, may we say, does forgetting proceed under the influence of disuse? Does one gradually retain less and less as time goes on? Experiments began with Ebbinghaus and have shown that the loss in retention is greatest at first and then grows less and less until there is practically no further decrease. Ebbinghaus' tests have been repeated, notably by Radossawljewitsch (see p. 282), and have been confirmed except that the later students have found a less rapid initial loss of retention. The following account summarizes the results of the two studies already mentioned upon nonsense syllables: According to Ebbinghaus, 55.8 per cent is forgotten at the end of an hour, and practically 75 per cent after 6 days. According to the more reliable data of Radossawljewitsch, 50 per cent is not lost until 8 hours have passed; but most of this is recovered on the following day, so that a permanent decrease of 50 per cent is not found for 6 days. Popularly one regards the rapid learner as the quick forgetter. Much evidence has been secured, however, indicating that the contrary is the case, and that the one who learns quickest also retains best.

The Fixation of Arcs in Habit.—We return now to the question of primary importance in our discussion of elimination. At the time neural associations are formed why are certain ones excluded? In this connection Watson has made use of the phrase, "the fixation of arcs in habit," in referring to the essential factors that

determine the fixing of acquired associations between reflex arcs. For convenience we shall phrase our statements positively and speak of factors making for fixation and retention, though we are at the same time pointing out the factors that make for elimination and forgetting. If, for example, the more recent response tends to be repeated, we are also saying that the less recent will probably be overridden by the more recent. Before enumerating and evaluating these different factors let us formulate the steps in habit formation in such a way that they will be as applicable to the formation of a typewriting habit as to the habit of repeating "My Country, 'Tis of Thee."

Angell enumerates the following stages in the formation of a habit: (1) appearance of the stimulus, (2) random movements, (3) accidental success, and (4) elimination of all or of most of the random movements. I see the typewriter before me. My hands make clumsy, awkward, slow movements. My body as a whole is strained and perhaps contorted. From time to time I make proper movements and succeed in my writing. Gradually my awkwardness vanishes, and I write accurately, at great speed, and with a minimum of effort. Let us take a laryngeal habit in order to illustrate the stages still further. (1) I see a list of French words and their English equivalents before me. (2) I repeat the list over and over with much bodily tension and with many random movements (mistakes) of the vocal organs. (3) From time to time I succeed in repeating portions of the list. (4) Errors are finally eliminated and the habit is complete.

Our fundamental question at present is with reference to the *elimination of random or unsuccessful movements.* Three investigators have presented views that require comment: Thorndike (1911), Carr (1914), and Watson (1914). The factors making for the fixation of associations, according to Thorndike, are frequency (the law of exercise) and satisfaction (the law of effect). Thorndike states these laws as follows:

The Law of Effect is that: Of several responses made to the same situation, those which are accompanied or closely followed by satisfac-

tion to the animal will, other things being equal, be more firmly connected with the situation, so that, when it recurs, they will be more likely to recur; those which are accompanied or closely followed by discomfort to the animal will, other things being equal, have their connections with that situation weakened, so that, when it recurs, they will be less likely to occur. The greater the satisfaction or discomfort, the greater the strengthening or weakening of the bond.

The Law of Exercise is that: Any response to a situation will, other things being equal, be more strongly connected with the situation in proportion to the number of times it has been connected with that situation and to the average vigor and duration of the connections.[3]

According to Carr, the essential factors are frequency, recency, and intensity. Watson favors only frequency and recency. In our own judgment there is every reason to believe that frequency, recency, and the facilitating and inhibiting effects of avoiding reactions and visceral disturbances are the important factors. Upon frequency all are agreed. A succession of responses that is frequently repeated is thereby learned, unless some inhibiting factor is active. The neural connection, underlying a movement recently made, retains a low resistance and so tends to be traversed again. The genuine dispute comes over the manner of formulating Thorndike's law of effect. Even as Thorndike has stated it there is a suggestion of mystery, and psychologists in general have aggravated the situation by saying that pleasantness and unpleasantness are factors influencing learning. The observable fact seems to be that certain stimuli set up avoiding reactions, such as spitting things from the mouth and removing the finger from injurious objects, and that certain stimuli set up widespread visceral changes, such as the changes in the activity of the digestive tract when the organism is affected by nocuous stimuli. Any stimulus-response co-ordination which occurs in connection with such stimuli will have its chances for reinstatement lessened. Let us illustrate this with the case of a child who is given bitter medicine. The child is stimulated visually by the spoon and auditorily by the parent's voice. The response made to these stimuli is the taking of the medicine. The

[3] E. L. Thorndike, *Animal Intelligence* (New York, 1911), p. 244.

gustatory stimulation from the medicine causes the child to spit, gag, and withdraw its head. The next time the child is offered the medicine he responds by withdrawing the head and even by gagging and spitting. The response of taking the medicine has been eliminated. A similar situation occurs when an infrahuman animal is punished by having to retrace a blind alley in a maze or when it receives an electric shock in a discrimination box. The responses which immediately precede the behavior set up by the punishment are thereafter inhibited and eliminated.

Curves of Learning.—So far in our account no comments have been made upon the progress of learning in the case of the formation of a specific habit. How does the elimination of random movements proceed? Is it a gradual process or is it one of relatively sudden changes? Most experimental studies of learning have contributed data upon this point, although much still remains to be done in the way of analysis of the factors determining the form of the learning curve as opposed to its length (the problem essentially of economical methods of learning). Curves presenting typical results were given in the chapter on "Phylogenetic Anthroponomy" (p. 57) and in the chapter on "Unlearned Behavior" (p. 185). The accompanying figure (Fig. 68) shows results secured in a classical experiment upon telegraphy by Bryan and Harter. The data upon which these curves are based were partly secured by questioning telegraphers and partly by experiment upon several individuals who were learning the trade. The latter subjects were tested at stated intervals during their learning period in regard to their ability to send and receive letters that did not make words, words that did not make parts of sentences, and co-ordinated groups of words. The curves show the progress through weeks of practice in terms of the number of letters that could be sent or received per minute. Attention should be drawn to the following characteristics: (1) There is rapid progress in the first part of the curve indicating a relatively easy and consistent improvement. (2) The receiving curve remains below the sending curve for the greater portion of the learning. (3) The receiving curve shows a period of little prog-

ress, or a *plateau.* (4) Each curve tends finally to reach a level of little progress—the level of final attainment. In explanation of the second characteristic Bryan and Harter present many factors that we cannot list, but all of which indicate the greater difficulty of receiving.

The characteristic of chief interest is that of the *plateau,* which results from a slowing up in the relative rate of progress. This feature is found in innumerable cases of learning. One begins to play

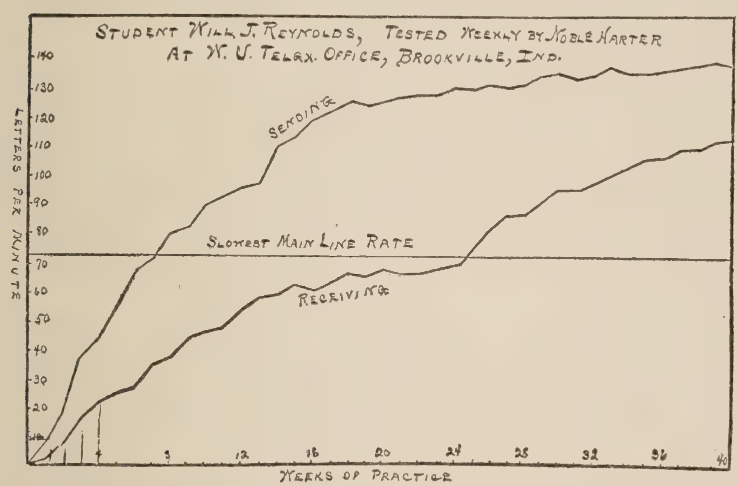

FIG. 68.—Learning curves for telegraphy secured by Bryan and Harter

tennis, for example, and advances splendidly for a time. Then try as one may, his serving remains inaccurate, or he returns the ball out of bounds. If vigorous work continues, however, this plateau will be passed perhaps in a sudden burst of skill that carries one to a much higher level. The same is true in chess, in golf, in typewriting, and in other habits. Some curves do not show plateaus, such as the sending curve just given and the maze curve on page 57. Plateaus may be due to any one of many factors of the following type: poor physical condition, lack of effort, use of inappropriate responses, and the formation of subsidiary habits. The last point is

the one stressed by Bryan and Harter, receiving being a complex, or hierarchy, of habits in which progress depends upon the mastery of the responses of least complexity. Habits must be built up for letters, words, and word-combinations. The first two are acquired easily, but the higher language habits come more slowly. "A plateau in the curve means that the lower-order habits are approaching their maximum development, but are not yet sufficiently automatic to leave the attention free to attack the higher-order habits. The length of the plateau is a measure of the difficulty of making the lower-order habits sufficiently automatic."[4]

We have emphasized but one characteristic of learning curves, and we have presented only one experimental study out of many dealing with it. Mention might be made of the fact that peculiarities in the rises and falls of curves have been used to differentiate learning which involves symbolic processes from learning of a haphazard trial and error type, but our knowledge is as yet too inexact to warrant more extended comments here. Enough has been said, however, to indicate the type of problem that arises in the study of the progress of habit formation or, negatively stated, in the progress of elimination of random movements. We must now turn to the question of the function of habits after they are formed.

The Function of Acquired Modifications of Behavior.—Acquired modifications of behavior, habits, are automatic responses that are called forth by the presence of any of a certain class of stimuli. There are stimuli for writing, for reading, for talking, etc., each class calling forth its appropriate response which has been built up on the basis of plasticity and retention, as we have described. What functions do these acquired responses serve? In answering this question we may well contrast instinct with habit. Instincts serve to adjust the organism to its environment in ways that have proved not too disadvantageous in the past history of the species. Likewise habits serve to adjust one to his environment in

[4] W. L. Bryan and N. Harter, "Studies on the Telegraphic Language: The Acquisition of a Hierarchy of Habits," *Psych. Rev.*, VI (1899), 357.

ways that have proved not too disadvantageous in his own lifetime. Each automatism *enables the individual to bring the results of past training to bear upon the present problems.* Solutions that have once been worked out may now be applied without repeating the process of learning. Speech is a solution of the problem of intercommunication; running is the rat's solution of the food-getting problem; and the automatic sequence of the verbal responses "Battle of Marne, 1914" is my solution of the problem "What is a decisive battle of the world war?" In either of these cases the association has been set up by having the essential parts retained and the erroneous, random parts eliminated. These habitual responses are "set off" by the appearance of their stimuli (problems) without relearning. *They thus conserve energy and increase the efficiency of response.* This function of acquired forms of response has its fullest development in that highest type of human behavior termed thinking, to a study of which we turn in the final chapter.

REFERENCES

Book, W. F. *The Psychology of Skill* (New York, 1925).

Bryan, W. L., and Harter, N. "Studies in the Psychology and Physiology of the Telegraphic Language," *Psych. Rev.*, IV (1897), 27–53.

———. "Studies in the Telegraphic Language. The Acquisition of a Hierarchy of Habits," *Psych. Rev.*, VI (1899), 345–57.

Carr, H. A. "Principles of Selection in Animal Learning," *Psych. Rev.*, XXI (1914), 157–65.

Ebbinghaus, H. *Memory.* Trans. by Ruger and Bussenius (New York, 1913).

Ewert, P. H. "Bilateral Transfer in Mirror-Drawing," *Ped. Sem.*, XXXIII (1926), 235–49.

Kitson, H. D. *How to Use Your Mind* (3d ed., Philadelphia, 1926).

Ladd, G. T., and Woodworth, R. S. *Elements of Physiological Psychology* (New York, 1911), Part II, chap. viii.

Meumann, E. *Psychology of Learning.* Trans. by Baird (New York, 1913).

Peterson, Joseph. "Learning When Frequency and Recency Factors Are Negative," *Jour. Exp. Psych.*, V (1922), 270–300.

Pyle, W. H. *The Psychology of Learning* (Baltimore, 1921).

Starch, D. "A Demonstration of the Trial and Error Method of Learning," *Psych. Bull.*, VII (1910), 20–23.

Strong, E. K. "The Effect of Length of Series upon Recognition Memory," *Psych. Rev.*, XIX (1912), 447–62.

Thorndike, E. L. *Psychology of Learning* (New York, 1913).

———. "A Fundamental Theorem in Modifiability," *Proc. Nat. Acad. Science*, XIII (1927), 15–18.

Watson, John B. *Behavior* (New York, 1914), chap. vii.

Watt, H. J. *The Economy and Training of Memory* (New York, 1909).

Wylie, H. H. "An Experimental Study of Transfer of Response in the White Rat," *Behavior Mon.*, III (1919), No. 5.

CHAPTER VII

THE CORRELATION OF STIMULUS AND RESPONSE

Introduction.—All behavior involves a correlation of stimulus and response. Not only do we say in general that responses are the result of stimuli, but we point out in particular that any change in either variable should lead the student to search for the probable change in the other. Where the correlation between a specific stimulating condition and a specific response is relatively fixed and permanent, we have to deal with instincts and reflexes or with habits. The former unlearned behavior has already been discussed in chapters ii and iii; the latter, in chapter vi. At present we are to consider certain of the general problems involving the relationship between stimulus and response. These problems are as follows: (1) What are the characteristics and the conditions of that behavior which is dominant at any one moment? (2) What are the conditions under which one form of behavior succeeds another? And (3) what are equivalent stimuli and equivalent responses?

DOMINANT BEHAVIOR

Each organism throughout its lifetime is constantly behaving. Stimuli are playing upon all or most of its receptors, and all of its effectors are active in greater or lesser degree. Even when the organism is standing still or resting, its effectors are responding either in such a way as to support the body or in the slight form known as tonic contractions. In addition to the activities of the skeletal muscles there are always present large numbers of visceral responses, digestive activities, circulatory changes, respiration, etc. From such an array of responses it is possible to select certain ones which may be said to dominate the behavior of the moment and to indicate other responses which serve as a general background of activity. Many of the responses which are in the background undoubtedly

aid the primary behavior either by making for a better reception of the stimuli or by reinforcing the primary behavior. The former case is illustrated by the changes in the muscles of the eyes controlling accommodation and convergence and by the turning of the head for the better reception of sound stimuli. The case of reinforcement will be illustrated below on page 314 in terms of the Traube-Hering waves of blood pressure.

At one time or another any kind of behavior may dominate the organism. Thus at one moment automatic visceral responses may be the most characteristic activities present. At the next moment some habitual response of the skeletal muscles, such as typing or speaking, may be dominant. However, the major response need not be automatic. Often it is an actual process of learning and of the solution of new problems of environmental adjustment which is the major response, rather than a mere reinstatement of forms of behavior which are already established and automatic.

There is only one method by which to determine what an animal is doing, and that is to observe the animal. A casual observation of external behavior is not always sufficient. Often it is necessary to study the internal behavior as well. Verbal responses are in many cases aroused by internal stimuli, as is the case when an individual exclaims because of visceral injuries. Because of this fact and because of the great rôle which verbal responses play in social behavior, many investigators have sought to use verbal responses as a means of determining the dominant behavior of the subject. In place of observing the subject's behavior in as much detail as possible, they ask him what he is doing or what stimuli are controlling his behavior. The sources of error in such a procedure are so great that it should be used only when it is impossible to observe the subject and when no other method is available. Even so the verbal behavior is to be treated merely as a form of response which may or may not be a correct symptom of what is taking place in the organism beyond the range of the experimenter's observation.

What are the conditions which determine that one form of behavior and not another shall be dominant at any given moment?

Why, from the thousand possible verbal responses that a subject might make, does he make this one and not that? To be sure, the presence of a stimulus either inside or outside the body is necessary, but this in itself is not sufficient to explain the selection. The great majority of stimuli have been conditioned to a large number of different responses, and so the mere presence of the stimulus will not explain why one related response and not another is active.

Conditions Peculiar to the Stimulus.—The conditions (selective agencies) which determine what form of behavior shall be dominant may be divided into two classes, characteristics of the stimulus and characteristics of the organism. The former are those characteristics of physical objects and events by virtue of which these phenomena either (1) get control of behavior or (2) lend themselves most readily to discriminative behavior. The first condition covers many everyday facts. Intense sounds, bright lights, strong odors, tastes, or contacts, all tend to get control of behavior. The same is true of moving things. Animals that feign death escape notice, while a mouse that moves catches the cat's eye. Throughout the animal scale, movement or change in the environment is almost irresistibly reacted to. The movement need not involve merely visual stimulation. The notes that make up the melody of a song rise and fall in pitch. In this manner they change in relation to the accompaniment, and accordingly they easily make the melody a determining factor in the control of behavior. The skin is more sensitive to movement than to the discreteness of stimuli. One can place the two points of the compass so close together on the skin of the forearm that they are reacted to, not as two, but as one. Suppose that this distance is 1 cm. If now one of the points is moved over a distance of ¼ cm., the subject can still discriminate the movement in spite of the fact that the distance traversed by the stimulus is less than the threshold for the discrimination of two points. A similar phenomenon occurs in peripheral vision, i.e., in the field of vision away from the immediate object upon which one's eyes are focused. If one holds his open hand far enough toward the periphery of vision so that each separate finger cannot be discriminated, move-

ment of any one finger can nevertheless arouse a discriminative response. This is confirmed by careful experimentation which indicates that the threshold for movement is lower than the threshold for discrete objects. The adaptive value of these facts for the organism is very clear, for moving objects are likely to be either food, mates, or enemies. It is very probable that stimuli of great intensity, loud noises, bright lights, etc., get control of behavior as much in virtue of the fact that they are changes from preceding noises and lights as by the fact of their intensities. *Movement, change, is the fundamental characteristic of the stimulus through which the control of behavior by that stimulus is established.*

In addition to those characteristics of objects in virtue of which we are forced to respond to them, there are other characteristics which enable us to respond accurately, the second characteristic of the stimulus which we mentioned before. These conditions have been carefully studied in reference to testimony. The problem is to determine the factors which condition not so much the organism's behavior to the presence or absence of a noise or other happening as the organism's discriminative behavior to the details of the event. Behavior, as we have seen, involves selection and discrimination. What aspects of the stimulus favor the discrimination of parts within a given total event? First, the object must not be presented for too brief an interval of time, for opportunity must be afforded for the organism to adjust itself to the new situation. Second, the objects must not succeed each other so rapidly that separate forms of response to the several parts are impossible. Exactly how much time shall be given will depend upon the complexity of the object and the amount of detail to be discriminated. We shall have occasion to describe data bearing upon this point later (p. 308) under the discussion of "accurate discriminative behavior" and "the scope of stimuli and dominant behavior."

Conditions Peculiar to the Organism.—By conditions peculiar to the organism we shall understand all of those determiners of dominant behavior which belong to the organism rather than to the stimulus. The first class of these determiners is the anatomical.

The *anatomical conditions* are the limitations imposed upon behavior—and of course upon neural activity also—by the number and character of the receptors. Of all the transformations and transfers of energy that go on in the universe, only certain ones are reacted to by man and infrahuman animals. At any one moment of time each organism is bombarded by innumerable stimuli. Ether waves and air waves of all ranges of frequency, pulls of gravity, changes in electric potential, etc., are the forces in question which may vary from moment to moment. It is these forces which constitute the environment in which the animal lives. The very conception of an organism's adjusting itself to its environment presupposes selection. At one moment it will react to light, at another to sound, and then to odor. This phase of its adjustment is absolutely determined by the number and nature of the receptors that the animal possesses. Receptors, as we have seen, are merely points on the organism which are particularly sensitive to certain forms of energy. That we do not have more of them and different ones must be due to the fact that those we have serve to select out or adjust us to those forms of energy which favor survival, which enable us to detect food and mates, and which aid us in determining locations that are injurious (painful), that are too cold or too hot, etc.

In addition to the anatomical conditions we may list the following additional organic factors: instincts, habits, and the laws of habit reinstatement. The second condition rests upon the third: the fact that if two forms of behavior have appeared in succession, when one reappears the other tends to follow. This we may term the fundamental law of the reinstatement of habit. Instincts depend upon inherited co-ordinations and represent original, innate modifications of the nervous system by virtue of which nervous impulses flow over one system of pathways rather than over another. A loud noise occurs. It dominates behavior by virtue of the fact that it is a sign of possible danger and therefore a stimulus for the instinct of fear. It is probable that we are by heredity compelled to respond to objects connected with food, sex, rivalry, play, curiosity, anger, fear, jealousy, and the remaining gamut of instincts. If or-

ganisms existed devoid of the anger instinct, threats against life and property would not determine behavior of the intense type actually observed, unless they were also connected with fear. Individuals in whom jealousy is dormant do not respond to certain events which are frequent stimuli for that instinct. The fundamental motives and interests are furnished by the instincts. This is inevitable, for they represent the solutions which have been found advantageous in the history of the race for certain important difficult situations, dangers, and other problems of primary importance.

The term "habit" covers customs, peculiarities of education, and individual idiosyncrasies. Habits are built up by the individual with the inherited forms of action as a basis. They serve to limit further the lines of action taken by the organism, to fix more definitely the objects to which he as an individual can respond, even as the instincts set the limits of his behavior as a member of a given species. Where the habits are passed from one generation to another by training, we speak of custom and tradition. It is a familiar fact that customary and traditional manners and stimuli are the things to which we respond. This is so to the extent that our behavior follows the socially accepted (selected) pattern. A carpenter starts to build a house or a cobbler to mend a pair of shoes. Each reacts to first this object, then that, and then the other, because that is the traditional way to build the house or to mend the shoes. A Chinaman's behavior is consistent with the conservative phases of action and with the avoidance of outsiders, because this is a customary mode of behavior in these matters. Perhaps language is the greatest custom of all. This "idol of the tribe," as Bacon would say, fastens itself on all men to some degree. A faulty vocabulary, *repertoire* of verbal responses, notoriously limits our thinking and curtails the things to which we respond. In addition to these habits, shared with other members of the social groups, there are those which arise peculiar to the individual or to the small group. These are the hobbies and professions of men. Objects to which we respond as behaviorists are neglected by others and even by ourselves when we are masquerading as laymen. The stimuli constitut-

ing an athlete's world are quite diverse from those making up the environment of a judge, and these differ much from those of other professions. A geologist reacts to objects that escape the eyes of ordinary mortals, and so the story goes. Each habit acquired helps to determine which stimulus-objects will be selected and thereby dominate behavior.

We turn now to a brief statement of the part played by the laws of habit reinstatement in conditioning behavior. The basic principle has already been stated: the fact that if two forms of behavior have appeared in succession, when the first one of them again appears the other tends to follow. These laws do not designate physical forces which control behavior, rather they formulate relationships which the experimenter discriminates between successive stimulus-response co-ordinations. If at one moment the letter *a* is spoken, *b* tends to be spoken next. This may be due to the frequency with which *b* has been spoken after *a*. It may be because *b* arouses the same general bodily disturbance that accompanies *a*; for it is a familiar fact that when I am gloomy, the reactions which I am prone to make are also "gloomy," and when I am joyful, only the stimuli relevant to this are markedly successful in getting access to the effectors. Or, again, it may be because *b* is consistent with *a*, i.e., fits into the general scheme of behavior then in progress. The selection of what shall dominate behavior is begun by the structures and functions of the receptors, is further completed by instinct and habit, and is then finished by the influence of the forms of behavior which have been dominate the moment before or which continue to dominate the organism. The action of each of these factors is conditioned by that of the ones that have preceded it in the list. The factors are given, therefore, in the order of increasing variability, going from the anatomical through all stages of the physiological. As the individual organism ages, however, customs become as rigid as instincts and as inflexible almost as the receptors themselves in giving novel stimuli access to the effectors. Here one has the almost rigid personality, where no essentially few forms of behavior ap-

pear. Figure 69 represents graphically this hierarchy of selecting factors.

Accurate Discriminative Behavior.—When a rat learns to discriminate correctly between the correct pathway and the cul-de-sacs in a maze and so runs the maze perfectly, we have an instance of accurate discrimination. This is also the case when the behavior of the human subject reveals that he has discriminated between two tones of different pitches, or that he has learned to respond to

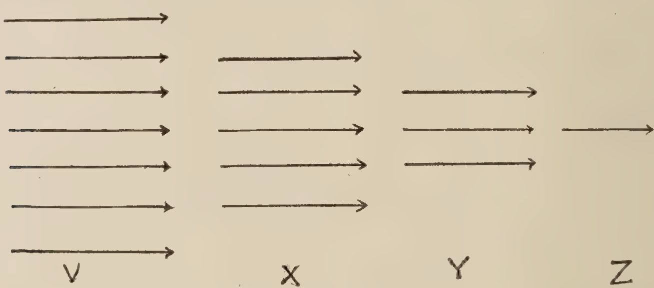

FIG. 69.—A diagrammatic representation of the conditions of behavior. *V*, forces outside the nervous system (they may be inside the body) which may or may not affect the receptors. *X*, anatomical conditions of behavior, the limited numbers, kinds, and capacities of receptors. *Y*, habitual and instinctive conditions of behavior such as habit and instinct. *Z*, the last condition of behavior, the neural activities immediately preceding any given response (see section on "Resulting View of Behavior," p. 181).

various specific partial vibrations in a given complex sound. Experiments of the foregoing type have been discussed elsewhere in this book. Our present problem is to canvas the general conditions which underlie accurate discriminations and thereby to understand more clearly the conditions which lead to the dominance of certain forms of behavior.

The most interesting experimental results for human subjects have been secured, notably by the German investigator, Stern, in the field of verbal testimony. Verbal testimony differs from the discriminative behavior described in the preceding paragraph only in these respects: it makes use of habits, learned stimulus-response

co-ordinations, which the subject has already mastered; and these habits are to be reinstated after the original stimulus has ceased to act. Thus the subject can respond verbally to each of the objects, colors, and events contained on a picture card if he is given time and if the card remains in the field of vision. Under these conditions the subject's verbal responses are highly accurate. Suppose, however, that the stimulus card is presented for a short time only. How many of the verbal responses can the subject now reinstate after the card has been removed? This is the typical problem in studies of verbal testimony.

The conditions of such an experiment are varied in such a manner that it is possible to determine among other things the effect upon the range and nature of the reinstatement of: the duration of the stimulus, the presence of surprise in the observer, the age and sex of the observer, and the presence of definite anticipatory reactions. We shall now comment upon these factors briefly so far as they deserve additional comment. Discrimination is most efficient if the observer is not fatigued and is not surprised by the sudden advent of the stimuli. Surprise is an emotional disturbance, and emotions narrow behavior to the particular stimuli that arouse them and to other closely related stimuli. Surprise thus turns the subject's behavior away from the experimentally proper stimuli and causes it to be dominated by other stimuli. Again, trained observers, e.g., artists and scientists, respond to those features of the object which are in line with their calling. With untrained observers Stern has found evidence that the objects responded to vary with the age of the subject. Thus, persons and things determine behavior at the age of seven years. From seven to ten, actions also determine the response. From twelve to fourteen, spatial and other relations are added, and after fourteen comes the qualities and properties of the objects. Color is one of the last things to determine verbal testimony. With the increasing age of the subject those characteristics of a situation are reacted to which lend themselves to a unitary series of responses as this is found in such verbal behavior as, "The picture shows a mother cooking for her child." There

seems to be no significant variation with respect to sex in tests of this type. Common observation would say that girls and women respond to many objects that are ineffective with men and boys. This, however, is a difference arising from training and not from innate organization.

By the influence of the *anticipatory reactions* before referred to, we mean that those stimuli are most likely to control behavior which will strengthen or harmonize with the behavior which the subject is already making at the time these stimuli are presented. Thus, if I am counting numbers, or if I am told to get ready to count numbers, and am then shown a card containing numbers, my discriminative behavior will be more accurate than it would be if the number card were presented after I had been told to count letters. This phenomenon is essentially the same as the influence of the instruction stimulus. Through the anticipatory reactions set up by the instruction stimulus the subject is prepared to respond to certain stimuli and to pass others by. The neural processes underlying such preparedness undoubtedly influence the effects of the new stimuli through facilitation and inhibition.

The Scope of Stimuli and Dominant Behavior.—Under this title we are to consider briefly an interesting little experiment that has been made upon the number of simultaneous stimuli which can call forth accurate discriminative behavior. In a very true sense any stimulus is discriminated which arouses a response. In as much as the whole organism is active at each moment, a very large number of stimuli are being simultaneously discriminated constantly. The experiment which we are to describe, however, deals only with one aspect of this large problem. This aspect is this: If stimuli are presented to one receptor for a very brief interval of time, e.g., one-fiftieth of a second, how many of the stimuli can be accurately discriminated? This is essentially an experiment upon testimony.

Sir William Hamilton, an English philosopher, was perhaps the first to cite an observation indicating a limit to the number of objects that could be responded to after a brief presentation of the objects. Hamilton says:

If you throw a handful of marbles on the floor, you will find it difficult to view at once more than six, or seven at most, without confusion; but if you group them into twos, or threes, or fives, you can comprehend as many groups as you can units; because the mind considers these group only as units,—it views them as wholes, and throws their parts out of consideration.[1]

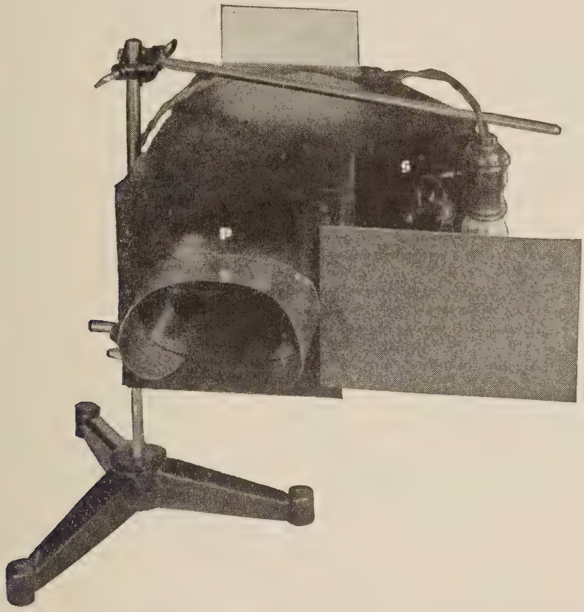

FIG. 70.—Dockeray's Camera-Shutter Tachistoscope. The subject looks through the openings at *P*. Light from the electric bulb passes through the shutter at *S* and is reflected from the stimulus-card, shown in the rear, to the subject at *P*. The duration of the exposure is regulated by the speed of the shutter. In this figure, the stimulus-card is raised from its normal position during experimentation.

This experiment in its modern form is applied in the field of visually determined behavior by means of a tachistoscope. Figure 70 shows a typical tachistoscope, with a description of some of the

[1] Sir William Hamilton. *Lectures on Metaphysics and Logic* (Boston: 1858), I, 177.

stimulus cards. The essential characteristic of the apparatus is its adaptation for presenting varying amounts of material, as shown on the card, for brief intervals of time, one one-hundredth to one-fifth of a second. Such an interval is too short to permit the separate objects on the card to arouse separate responses during the exposure. It has been shown, under these conditions, that only four or five objects are effective in determining the subsequent behavior of the subject. These objects may vary much in complexity. Four short words will serve as well as four letters; four groups of two lines each (// // // //), as well as four single lines. The more relevant the stimuli to the habits of the subject, the more stimuli will be effective, e.g., if words are arranged as a sentence, more words will be effective than if they are shown as a disconnected group. Similar results are obtained with sound stimuli. Clicks that are given too rapidly to determine separate responses, while the clicks last, are effective on the average in spans of not more than eight. If, and to the extent that, rhythm is introduced within the group of eight, more and more clicks may be effective up to thirty or forty.

Fluctuations in Dominant Behavior.—In a certain very real sense the individual organism may be dominated by a given type of response for long intervals of time. One may be engaged in writing a book, in painting a picture, or in building a nest for days or months. What is really happening, of course, is that the individual is writing for only a few hours each day. Even during these few hours, he is not writing steadily, but he is doing any number of other things as well. These changes in dominant behavior are due to a variety of factors among which changes in the stimuli and in the subject's physiological condition are important.

Even, however, when we consider a single stimulus and the response which it elicits, there are fluctuations in the behavior. Suppose, for example, that our subject is given the instruction stimulus, "Press upon this electric key when the stimulus is present, and release the key when the stimulus is absent." Then present a faint visual or auditory stimulus which is in itself constant and not intermittent. The result will be that the subject will press and release

the key in a fairly regular manner. If the key be connected with a pointer which writes on the smoked paper of a kymograph drum (Fig. 71), a record similar to that of Figure 72 can be secured. Although the stimulus is constantly present, it is only intermittent-

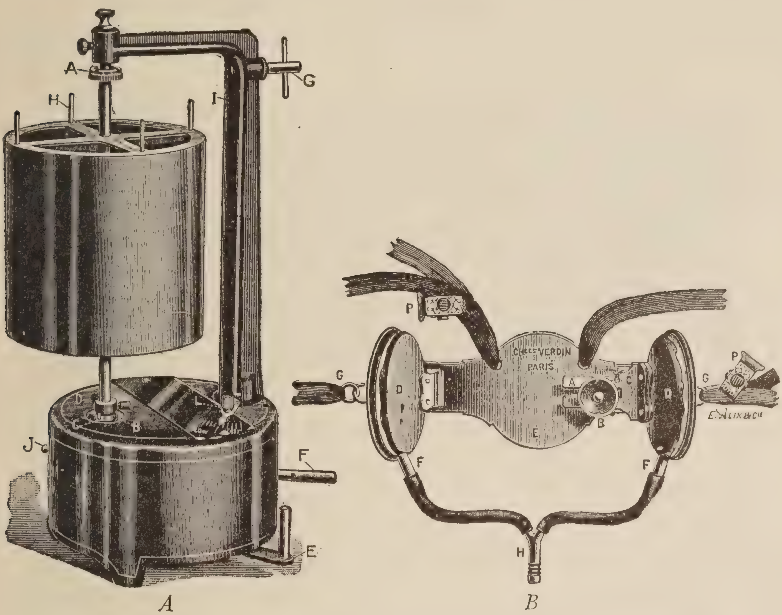

FIG. 71.—The apparatus *A* is a kymograph. The drum rotates at a variable speed and is driven by a spring within the base.

The apparatus *B* is a pneumograph. The tape at *G* and *G* is placed around the subject's body so that expansion and contraction will pull upon the rubber membranes attached to *D*. These changes are transmitted as puffs of air in the tubes *F*, *F*, and *H*. They finally reach a marker which records on the kymograph drum.

ly effective in determining behavior. This intermittent effectiveness of faint stimuli has never been adequately explained. There are, however, several excellent possible explanations. (1) The retina may, through fatigue and recovery, make the stimulus effective only during certain periods. (2) Changes may occur in the muscu-

lar adjustment of the receptors whereby the effectiveness of the stimulus is varied. The ciliary muscle, for example, which controls the adjustment of the lens may vary sufficiently in its state of contraction to change the effectiveness with which the stimulus acts upon the retina. And (3) there may be rhythmical processes in the body which set up neural changes that intermittently reinforce the

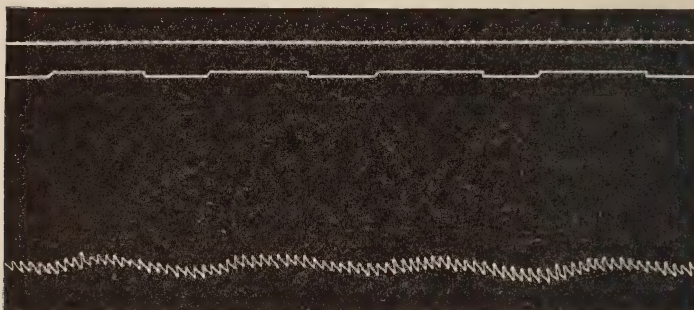

FIG. 72.—This figure represents one type of record taken on the kymograph in the study of the fluctuations of behavior. The top line is a record of seconds. The middle tracing indicates the fluctuations of behavior to faint visual stimuli, periods of stimulus effectiveness being indicated by the higher levels and periods of ineffectiveness by the lower ones. The lower curve shows the variations in the volume of the finger caused by the pulse beats and the Traube-Hering waves. Particular attention is called to the parallelism between these latter waves and the fluctuations of behavior (from J. W. Slaughter, *Amer. Jour. Psych.*, XII [1901], 313–34).

neural impulses set up by the faint stimulus. Such rhythms seem to exist in breathing and circulation changes. In the latter case rhythmical waves of nervous activity apparently originate in the medulla and produce regular changes in blood pressure. These waves of blood pressure are termed Traube-Hering waves, samples of which are shown in Figure 72. It is possible that the same variations in neural activity which produce the changes in blood pressure may influence the effectiveness of faint stimuli through periodic reinforcement of the neural processes set up by those stimuli. To the

extent that this is true, the rhythmical waves of neural activity may be listed as another of the conditions determining what behavior shall be dominant at any particular moment.

THE CONDITIONS OF HABIT REINSTATEMENT

In the discussion of the conditions of dominant behavior we had something to say concerning the factors underlying habit reinstatement. The laws of this process are formulated to cover various aspects of the following observable phenomena: (1) when two forms of behavior have occurred in succession, the second form of behavior will probably be reinstated if the first one is rearoused; and (2) when *many* forms of behavior have been connected, or integrated, as described in (*1*), the appearance of any one of the responses will probably be followed by the reinstatement of some *one* of the others. Let us illustrate. (1) The visual stimulation from the letter *a* will, as a result of training, call forth the vocal response *a*. This stimulus-response co-ordination has often preceded that where the visual stimulation from the letter *b* calls forth the verbal response *b*. The result, after this period of training, is that the visual stimulus *a* will call forth the verbal response *a*, which will then be followed by the verbal response *b*, although the visual stimulus *b* is not then present. As a result of similar training the subject learns to say all the letters of the alphabet when the letter *a* alone is presented. (2) In order to illustrate (*2*), let us assume that the stimulus-response co-ordination *a-a* has been immediately followed by *b-b*, *c-c*, or *d-d* an equal number of times. Now when the subject is stimulated by the letter *a* and responds *a*, he may next respond either *b*, *c*, or *d*. Because of a training similar to this, when I see the word *Roosevelt*, I may say either "president," "colonel," or "hunter." I cannot say all of them at once. I must say one, to be followed perchance by the others one at a time.

The Mechanism of Habit Reinstatement.—Figure 73 will help us to understand the general mechanism involved in the phenomena just described. The vocal responses set up air vibrations and muscular strains which constitute auditory and kinaesthetic stimu-

li, respectively. The nervous processes which follow these stimuli become conditioned, or associated, with subsequent responses so that either the auditory or the kinaesthetic stimuli may arouse those responses. These stimuli are thus substitutes for the visual ones. In order to bring about this conditioning one must follow the general procedure of all conditioned reflex experiments: There must be no serious distraction or fatigue. And the responses must be arranged so that the conditioning will be in a forward, rather than in a backward, direction. Under these conditions frequency of repetition seems to be the positive factor underlying the possible reinstatement of habits II, III, and IV.

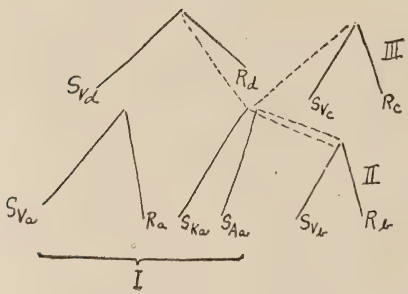

FIG. 73.—Stimulus-response co-ordinations involved in habit reinstatement. S_{V_a} visual stimulation from letter a; R_a, verbal response a; S_{K_a}, kinaesthetic stimulus set up by saying a; S_{A_a}: auditory stimulus set up by saying a. These together constitute habit I. S_{V_b}, S_{V_c}, S_{V_d} and R_b, R_c, R_d refer to the same facts for the letters b, c, and d. Habits II and III are as complex as habit I; but for purposes of the diagram, the auditory and kinaesthetic stimuli which are aroused in these habits are omitted.

Let us now consider the case where habits II, III, and IV have each been conditioned to habit I. When habit I is reinstated, which of the other three will follow? In this situation the determining factors will be: relative frequency, recency, and facilitation. Concerning frequency nothing more need be said. Other things being equal, that behavior which has been most frequently connected with habit I will follow it. And so, other things being equal, that behavior which has been most recently connected with habit I will follow it. An additional comment is required concerning facilitation. Facilitation occurs both at the time of the original conditioning and at the time of the reinstatement. This can be

illustrated best by the influence of instinct upon learning. If a person has been in an automobile accident where he has manifested fear, the great mass of neural impulses set up by the widespread bodily disturbance will have facilitated the conditioning of "automobile" and various responses such as trembling, or stomach movements, or even the vocal response "bad accident." Thereafter the stimulus "automobile" is followed by one of these originally facilitated responses rather than by some response more frequently or recently conditioned to automobile. Facilitation is also present at the time of the reinstatement of a habit. When an individual is talking about athletics, the habits which are reinstated are those which have been conditioned to the athletic situation. When one is at tea, the habits which are reinstated are those which have been built up in situations of the same general character. When anger dominates the organism, the responses which are reinstated are those which have been conditioned to anger-producing situations in the past. Each total behavior situation, whether or not it involve instinctive responses, facilitates the reinstatement of those responses which in the past have been conditioned to that situation. We must, therefore, expect this influence to show itself in determining which particular habit shall be reinstated after the appearance of another particular habit. If the subject is in an angry situation, the individual responses which he makes will be consistent with this particular situation, other things being equal, rather than with others, such as study and dancing. (Wherever we have spoken of the facilitation of certain responses we might well have spoken of the inhibition of others. Not only are angry responses facilitated in the case just described, but the responses of dancing are inhibited.)

If we were to generalize the results of the present section with reference to the correlation of stimulus and response, we should merely reaffirm that all responses occur as a result of stimulation. Even in the sequences of responses which we have described under the topic of habit reinstatement this is true. Habits II, III, and IV, e.g., may finally be set off by internal kinaesthetic stimuli and

so give the appearance of being divorced from a stimulus, but this is appearance only. The kinaesthetic processes are vital factors in the occurrence.

THE EQUIVALENCE OF STIMULI

Examples from Vision.—When the same response can be aroused by any one of several stimuli, these stimuli are termed equivalent. The illustrations of this phenomenon are legion. In Figure 74 the two stimuli marked I will arouse the same behavior

Fig. 74.—Equivalent stimuli from the field of vision

as the two stimuli marked II when the subject is given the instruction stimulus "Point to the longer line." Figure 75 is a complex stimulus which will be responded to in either of three ways, when the subject is properly instructed: (*a*) the subject may respond as he would to a drawing of a stairway seen from above, or (*b*) as seen from below; or (*c*) he may respond as he would to a plane surface containing a design. Since the external stimulus in this figure remains constant although the behavior of the subject changes, we must look for the explanation in terms of processes going on within the subject's body. The subject has at least three specific habitual forms of response which he has learned to make: one to flat designs, one to stairlike structures seen from below, and one to these structures seen from above. These three specific responses may be verbal ones: "That is a design," "That is the top of the

stairs," "That is under the stairs." Where nothing in the general stimulating situation serves to reinforce one of these forms of behavior at the sacrifice of the others, the subject manifests first one and then another of the responses for which the figure is the stimulus. If the subject's eyes are focused on *a* in the figure, the response to the figure as seen from above will almost certainly occur. The opposite response is more readily elicited if *c* or *b* is fixated. (With so small a figure, steady fixation is difficult.) Focusing the eyes

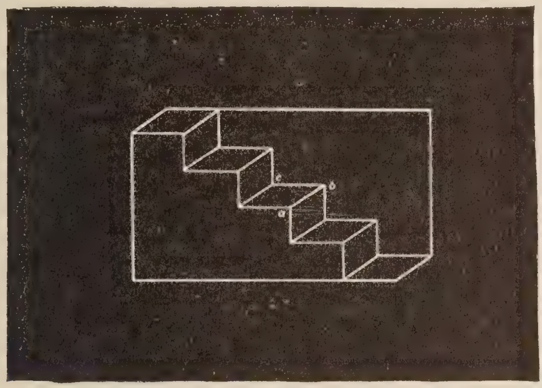

FIG. 75.—A complex visual stimulus which calls forth several different types of response.

upon a stimulus is an integral part in the total response of reacting to that stimulus as nearer than other stimuli less clearly focused upon the retina. It is, therefore, not unexpected that such a process of focusing the eyes should facilitate the type of behavior which we have described.

Equivalent stimuli may be readily illustrated from the field of verbal responses. The three stimuli, *Er ist zu Hause, Il est chez lui,* and *He is at home,* are equivalent in as much as they arouse the same responses in one subject or in subjects belonging to different language groups. And so one combination of English words may be equivalent to another combination of English words, an equivalence

based upon the identity of the response to which both stimuli lead. In the same way the visual stimulation from a box is equivalent to the auditory or the visual word box.

Examples from Learning.—The two following examples will serve to illustrate the phenomenon of the equivalence of stimuli in the field of habit formation. (1) Human subjects, who respond with a flow of saliva when stimulated by food in the mouth, can be trained to make the same response to a whistle, to a dinner-bell, or to the kinaesthetic-auditory sensory processes involved in the verbal response "toast and coffee." Again, these subjects can be trained to make the same response, e.g., that of halting, to such a variety of stimuli as red traffic lights, the auditory stimulus "stop," and a sudden intense sound. (2) An experiment (Hunter, 1918) performed upon rats may well supply us with our second illustration. In a T-shaped maze, rats were trained to run through the right side of the apparatus when a whistle was sounded and through the left side when silence was present. These responses the rats could make with a high degree of accuracy even in the dark, in as much as visual processes played no necessary rôle in the control of the behavior. A control test was now tried. With the apparatus in the dark, a light was turned on in the central alley in place of sounding the whistle. Darkness took the place of silence at the next trial. Under these conditions some of the rats ran to the right for the light and to the left for darkness, although they had never been trained to respond so to light and darkness. Even without this specific training, these stimuli were equivalent to those of whistle and silence.

Examples with Undetermined Stimuli.—The number of internal and external stimuli which can arouse behavior is so large and our knowledge of the specific internal stimuli is so slight that in practice we are often unable to determine what stimuli are equivalent one to the other. For example, the stimuli derived from an apple are often sufficient to arouse the response of eating the apple. It occasionally happens that a human subject makes all of the responses of eating an apple although there is no apple present. The

responses are essentially the same, and we know one stimulus which elicits the response. We do not know, however, precisely what stimulus functions in place of the apple when the apple is absent. Nevertheless, in as much as the phenomenon is quite similar to the others which we have described, we are justified in believing that some stimulus, probably internal, is controlling the behavior in the rôle of a stimulus equivalent to the apple.

We need not choose our illustration in such extreme form as that of the response to the apple, a response which might well occur in hypnosis or in hallucinatory behavior (see p. 105). For example, a subject has learned to make the verbal response "I see the house" when stimulated visually by a house or by a picture of a house; or the habit has been formed of making the verbal responses "I see blue," "I hear the radio," and "I smell the rose" upon the presentation of the appropriate stimuli. Many times, however, these responses are reinstated in the absence of the customary stimulus (house, blue, radio, or rose) and without the experimenter being able to say precisely what factor is responsible for the reinstatement. Until we have a detailed knowledge of the past history of verbal responses in some human subject we shall be unable to explain accurately and specifically such behavior as we have described. From infancy on, verbal responses are being elicited by a growing number of stimuli, and the interrelations of these stimulus-response co-ordinations grow more and more complex and difficult to trace. Unless, however, our conclusions on the general problem of habit reinstatement are unsound, the present cases are merely concrete examples of habit reinstatement. As such they are initiated by substitute stimuli which through training have become the equivalent of the original stimuli. These substitute stimuli, in any specific case, secure control of the vocal muscles through the aid of such factors as recency, frequency, and facilitation.

Equivalent Stimuli in Individual Subjects.—Do some subjects have an unusual skill in the use of substitutes for visual stimuli, or for olfactory stimuli? Do some subjects have more substitutes for visual stimuli than for olfactory ones, as a result of which

the subjects are greatly handicapped by the absence of the original olfactory stimuli, but not by the absence of the original visual stimuli? If we could arrange a suitable experiment would we find that subject No. 1 was 20 per cent more skilful than subject No. 2 in dealing with situations which could be met only by depending upon visual cues, and would we find that the same difference in skill existed if the visual cues were eliminated and the subjects forced to depend upon substitutes for the visual stimuli, i.e., upon equivalent stimuli? (These subjects we should want to be of equal general ability in order that the difference in specific skill might not be due to this general factor.) Or again, suppose that we could canvass completely the *repertoire* of behavior in two subjects, would we find that one subject possessed, let us say, one thousand substitutes for visual stimuli and two hundred substitutes for olfactory stimuli, whereas with the other subject these numerical values would be reversed? Such questions are questions of fact and not of theory. They cannot, therefore, be answered in advance of experimentation; but unfortunately the necessary experiments have never been carefully carried out. Investigations have been made by psychologists (notably Galton, Segal, Betts, Mabel Fernald, and J. R. Angell) in which an effort has been made to answer these questions; but the problem has always been formulated as that of the discovery of "image-types," i.e., are certain subjects "visualizers," "audiles," or "motiles," and as a consequence the methods adopted have not been well adapted to the solution of the problems which we have just formulated. The second of these problems would be very difficult to solve because it requires a complete canvas of the subject's behavior possibilities. The solution of the first problem, however, should encounter no difficulties beyond the reach of present-day experimental technique.

THE EQUIVALENCE OF RESPONSES

Two stimuli are equivalent when they will arouse the same response. One response is equivalent to another when it produces the same result as that other. Thus, an oriole and a robin manifest dif-

ferent nest-building behavior, and yet the two results are equivalent in that each serves as an adequate shelter for the eggs and young. Two mechanics may behave quite differently in constructing a piece of apparatus, and yet the behavior of the one is equivalent to that of the other when measured in terms of the end-product of the activity. In spite of the equality of responses which we have indicated there are often great differences in other respects. One series of responses may involve more fatigue, greater preliminary training, or a greater amount of unnecessary movement than the other. This method of classifying responses as equivalent one to the other in terms of the result attained is widely used. It is upon this basis that all animals are said to manifest food-getting behavior, anger, or locomotion. The actual responses made by insects, worms, rats, apes, and men in these three activities are extremely diverse; and yet, from the standpoint of the results, there is a sufficient equivalence to warrant speaking of a form of behavior which is common to the species indicated.

There is another type of behavior result which is possibly more significant than that which has just been discussed. All responses set up stimuli for further responses either by the same organism or by another. When a muscle contracts, kinaesthetic stimuli result. If the air is set in vibration, as in hand-clapping or in speaking, auditory stimuli are created. If the moving part of the body is in the field of vision, visual stimuli also result. Equivalent stimuli have already been defined. We are, therefore, ready for the statement that *where two responses result in equivalent stimuli, the responses themselves are equivalent* (Fig. 76 gives a graphic representation of these definitions). Let us illustrate this. (*a*) Sneezing in one subject may stimulate another subject auditorily and so cause him to jump. Subject No. 1 may now prick subject No. 2 with a pin and elicit the jump again. Sneezing and pin-pricking are thus equivalent because they result in stimuli which lead to the same response. (*b*) Subject No. 2 may be brought to a sudden halt when subject No. 1 calls "Danger!" or when he sounds an automobile horn. The behavior of calling "Danger!" and that of sounding

the horn (both forms of behavior in subject No. 1) are thus equivalent responses because they result in stimuli which are equivalent (in that they call forth the same response in subject No. 2). (*c*) Subject No. 2 may weep as a result of being stimulated auditorily when subject No. 1 says "I am going home." He may also weep when he reads "I am going home" written by subject No. 1. The

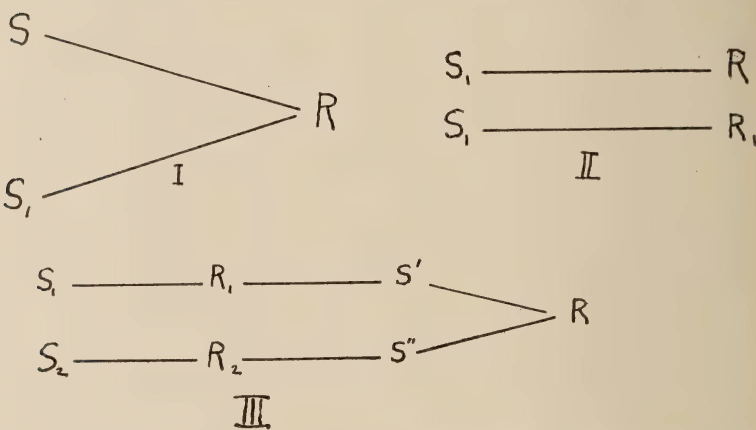

FIG. 76.—Equivalent stimuli and responses. I, stimuli (equivalent) which lead to the same response. II. The responses R and R_1, although aroused by different stimuli, are equivalent because both have the same result, food-getting. III. R_1 and R_2 are equivalent because they result in stimuli (equivalent) which lead to the same response.

verbal response and the manual response are thus equivalent because they produce stimuli which lead to a common response.

The existence of equivalent stimuli and responses enormously complicates animal behavior and makes it more adequate to cope with environmental difficulties. Such stimuli and such responses reach their greatest value for the organism in social behavior and in that form of behavior termed thinking. Thus, in social life it makes little difference whether I say "run" or make a manual gesture. The consequent response in another subject is the same, providing he has been properly conditioned to these two stimuli. The

behavior of French, German, and English people are not fundamentally different in spite of the great language differences. The various verbal responses that make up one language find their *equivalents* in the other languages, equivalents composed of verbal responses which lead to the same final behavior of eating, drinking, or building machines. In the following chapter we shall have more to say on this topic in connection with the nature of thinking.

REFERENCES

Billings, M. L., and Shepard, J. F. "The Change of Heart Rate with Attention," *Psych. Rev.*, XVII (1910), 217–28.

Fernald, Mabel. "The Diagnosis of Mental Imagery," *Psych. Rev. Mon.*, XIV (1912), No. 58.

Ferree, C. E. "An Experimental Examination of the Phenomena Usually Attributed to Fluctuations of Attention," *Amer. Jour. Psych.*, XVII (1906), 81–120.

Hunter, W. S. "Some Notes on the Auditory Sensitivity of the White Rat," Psychobiology, I (1918), 342 ff.

Kent, G. H., and Rosanoff, A. J. "A Study of Association in Insanity," *Amer. Jour. Insanity*, LXVII (1910), 37–96.

Oberly, H. S. "The Range for Visual Attention, Cognition, and Apprehension," *Amer. Jour. Psych.*, XXXV (1924), 332–52.

Pillsbury, W. B. *Attention* (New York, 1908).

Stern, W. *Beiträge zur Psychologie der Aussage* (Leipzig, 1905).

CHAPTER VIII

THINKING

Introduction.—Thinking is the form of behavior which enables man to make his most complex and varied environmental adjustments. By this statement we do not mean that all thinking behavior is superior to non-thinking behavior. Many habitual responses which do not involve thinking may meet the environmental difficulty as well or better than thinking. Many of the habitual responses of an expert are superior in efficiency to the thoughtful behavior of the layman. In spite of these facts, thinking is the behavior which stands at the apex of man's advancing control of the world in which he lives. It is the tool by which he makes most of his discoveries and by which he has outdistanced his animal competitors. In the discussion of the behavior differentia of man (p. 19), we listed three characteristics which set him off from the infrahuman animals: language, civilization, and the use of tools. Of these three, the first is fundamental and underlies the other two. Without language, civilization and the use of tools would be impossible. In the present chapter we shall see that without language thinking also would be impossible.

What, then, is this thinking behavior to which we attach so much importance? Although this mode of response is limited to the higher animals and is characteristic of *Homo sapiens,* it can in no sense be called an instinct. Man thinks and also learns, but the possibility of the two processes is all that heredity provides. Individual cases of thinking are no more inherited than are specific instances of learning. Indeed, all thinking behavior is learned behavior, although not all learned behavior is thinking. In envisaging the nature of one of these processes we must compare it with the other. If thinking is intimately related to habitual behavior, it is also inseparable from language. We shall not attempt to define

thinking at this point. We shall merely add that it involves problem solution; and, having said this, we shall pass to a brief statement concerning the nature of language.

Language.—Language responses occur most typically in the form of spoken and written words, vocal and manual verbal behavior. In addition to this verbal behavior, language includes gestural responses, such as beckoning and nodding the head in affirmation. There is no sufficient evidence that either of these forms of language behavior occurs in the infrahuman animals. Responses to stimulation are found in all animals, and language behavior involves response to stimulation. We can, however, point out several important ways in which language behavior differs from other forms of response. Verbal and gestural behavior are processes (*a*) which can be reinstated in the absence of the original stimulus that called them forth, (*b*) which function in the place of other less abbreviated forms of response, (*c*) which can determine one of two or more externally possible forms of behavior, and (*d*) which have a high social utility in the field of interstimulation and response.

All of these characteristics may be found in non-language responses, but no non-language response possesses all of them. Thus, a conditioned salivary reflex is aroused by a stimulus which is a substitute for the original stimulus; but the reflex has little or no social value. It is no more abbreviated than the unconditioned response, and it is doubtful whether or not it can arouse selective behavior. In contrast to this, the verbal response "On the right" is more abbreviated than the response of going to the right for which it is a substitute. It can be reinstated in the absence of the usual external stimulus and so can determine that the subject shall go to the right when a response to the right was physically possible. And last, the verbal response has a marked social value. When the substitute for the original stimulus lies within the organism, i.e., when it can be aroused by the organism's own activity through the self-stimulation of receptors, the organism has an independence which it could not otherwise possess. If in addition the substitute behavior is more abbreviated than the original, and hence more eco-

nomically and efficiently performed, the organism has a doubly valuable mode of adjustment.

The utility of these verbal and gestural responses for the individual and the group is so great that each individual receives an extraordinary amount of training on these forms of behavior, being given a verbal response for most of the characteristics of the stimuli which he will meet. The result is that he soon possesses a large *repertoire* of verbal response substitutes for definite stimuli outside of his body, for indefinite stimuli inside his body, and for forms of behavior which he and others make. These verbal substitutes are so intimately connected one with another by training that it is possible for any verbal response which is present to rearouse almost any other verbal response. In this way, when the organism is in difficulty, sooner or later the verbal response which can bring about the solution of the difficulty will appear.

Language is itself a symbolic process which in man reaches its greatest development in verbal behavior. It must not be forgotten, however, that not only the verbal behavior but any stimulus-response co-ordination may be a symbolic process (p. 67) to the extent that it has the characteristics which we have listed for verbal and gestural behavior. A movement of the hand, a contraction of muscles in the leg, or movements of the eyes may serve as symbols to control the behavior of the individual in the absence of the original and less abbreviated forms of response. Symbolic processes have been most highly developed in the vocal mechanism, probably because the vocal mechanism arouses sounds which can stimulate other organisms at a distance and without the aid of vision.

Many equivalent forms of verbal response exist, because through training many different verbal responses lead to the same behavior results. Thus tables of synonyms may be compiled for one language, and tables of equivalent words, for different languages. The actual behavior in saying "He is at home" and "Er ist zu Hause" is different in the two cases; but each verbal response is a substitute for the same gross behavior, and each leads to the same result with subjects who have been trained in the use of these

symbols. "He is at home" and "Er ist zu Hause" are, therefore, as much alike, if not more so, than are the food-getting activities of two animals of different species.

There is only the most superficial similarity between the verbal responses of a man and those of a parrot. Parrot-talk has not been developed as a substitute for other forms of behavior, such as walking and pecking. It does not determine what the parrot will do, nor does it have an organized interstimulation and response value among parrots. Many verbal and gestural responses in man are also parrot-like in that they are automatic responses to present stimuli with little or no value as substitute forms of response. The human subject, when properly stimulated, may say "Yes," "No," or "There it is" quite automatically and with no influence upon his own behavior. In such cases it is doubtful whether the response has any language value. In order to rank as a typical language response the individual's behavior must not be so automatic that it has temporarily or permanently lost its connections with those other forms of behavior for which it is a substitute.

In our discussion of the delayed reaction (pp. 65–67) we saw reason for believing that raccoons, apes, and children possessed symbolic processes. In order to solve the delayed reaction experiment the subject must develop within its own body substitutes for the external (light) stimulus. The three species mentioned were not only able to do this, but they developed substitutes which the experimenter could not observe and which could be lost during the interval of delay and reinstated later in time to control a correct response. Such substitutes we called symbolic processes. These processes apparently had all of the functions of language except the social characteristic of interstimulation and response. It is, therefore, probable that true language, as we have defined it previously, grows out of the symbolic processes used by some animals in the solution of the types of problem represented in the delayed reaction experiment. The possession of such behavior possibilities makes the organism independent of the controlling influence of ex-

ternal stimuli. He is now able to behave with reference to absent objects in a way that makes science, religion, and the arts possible.

Concrete Cases of Thinking.—Our understanding of the nature of thinking will be aided if we have before us one or two concrete instances.

(1) Suppose we place the subject in a room from which he can escape only through a single door. The door is fastened by a latch which is opened by pressing upon a push-button concealed in the knob. The subject, let us say, is an adult and has often been in rooms from which he has escaped by various methods. Having formulated his present problem, he may effect his escape by either of two methods, either without much use of verbal behavior or with the use of a very great many such responses. The subject may remain generally inactive while first one and then another verbal response is made, and only finally need he manifest general bodily activity controlled by one of the verbal responses. He may, i.e., sit down and reinstate the following: "I must get out of this room. The windows are too high to reach, and I can't climb to them. If I did succeed in reaching them, I couldn't get to the ground without serious injury, nor could I signal anyone. Everyone in the town has gone to the fair. No, the door is the only possibility. I have no key; and the knob won't turn. What is that odd button on the knob?" The subject goes over to the door. "Maybe the button opens the door. Push the button." The door opens, and the subject escapes. He might have attempted to solve this problem, not in terms of verbal symbolic processes, but by random responses of hands and legs, in the course of which trials he might incidentally have pushed the button and effected his release.

Some problems, like the maze situation, do not lend themselves to solution in symbolic terms. While learning the ordinary maze that is traced with a pencil, the human subject manifests many verbal responses, but these enable him to learn no more quickly than the subject who depends upon random manual responses alone. If, however, the order of the turns in the maze can be designated verbally as "Keep along the left side for two turns and then follow the

right side," then symbolic processes may be used with profit in the solution of the problem.

One should not infer that the random, trial and error activities which we have mentioned are peculiar to manual and other non-symbolic responses. By random activities we mean responses which do not help lead the subject directly to the solution of his problem. Many verbal habits are aroused in almost every problematic situation which confronts the human subject. The number that will be aroused seems to depend largely upon the wealth of verbal habits which the subject has to reinstate and upon the difficulty of the problem to be solved. The chief factors which seem to limit the variety of random symbolic or non-symbolic processes is the inhibiting influence of the experimental setting. Thus, our human subject will respond with a great many verbal responses when confronted with a difficult problem in maze learning, but it is very unlikely that he will recite poetry or sing classical music. And the cats that Thorndike once experimented with, by confining them in boxes from which they could only escape by manipulating a lever, struggled and scratched. They did not purr or yawn.

(2) Let us take another illustration of thinking and comment upon it. Professor J. C. Peterson, of the Kansas Agricultural College, told me long ago of the following problem, and I have since then tried it with many college students as subjects. The apparatus calls for a series of discs graduated in size from small to large. On a piece of paper three circles are drawn and numbered 1, 2, and 3 (see Fig. 77). Place three discs on circle 1 with the larger one at the bottom and the others in order of size. The subject is instructed, visually or auditorily, as follows: "Move the discs from circle 1 to circle 3 in the fewest possible moves. No disc is to be put upon one smaller than itself. Only one disc can be moved at a time, and it must be placed within one of the three circles. When you have mastered the problem for 3 discs, the number will be increased to 4, 5, 6, 7, etc. You are to learn to state a rule which will govern *all* moves that need be made with any number of discs. You are also to write the equation which will give the least number of moves re-

quired to solve the problem for any number of discs." The experimenter keeps a record of the number of moves made by the subject on each trial with each number of discs. The subject may work with these data in formulating his equation.

The first problem which the subject confronts in this experiment is to learn to say the rules and to make his manual behavior conform to them. He formulates the problem himself by re-giving himself the instructions, and then proceeds to respond. If he has not completely inhibited all movements contrary to the instructions, the experimenter must correct the movements by repeating the instruction which has been violated. From time to time as the subject works upon the problem of moving the discs he states a rule which he then checks by actually behaving according to the rule. If the tentative rule is "Always begin by moving the top disc to circle 3," trials with four discs soon prove the inadequacy of the rule. By this constant checking of hypothesis against fact, symbolic process against the behavior which it is to control, more and more efficient formulations are secured which are then followed until they can be changed for the better. This same trial and error reinstatement of old habits and their modification goes on in securing the mathematical formula. Few college students solve both problems correctly. The first rule is usually formulated only in a partially correct form, so that it controls most of the moves, leaving the others to be controlled on the basis of responses to the arrangement of discs at any one moment. Thus, the subject says, "The general rule does not fit here, but you just move like this." The problem which he has been set, however, calls for a rule to cover every move required for the solution of the problem. (In order that the reader may have an opportunity to work with this very

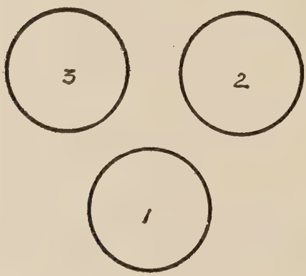

Fig. 77

interesting example of the development of scientific thinking, I shall not give the solutions!)

What Is Thinking?—On the basis of an analysis of the foregoing illustrations we may recognize the following steps in any typical thinking behavior: (1) The organism is confronted by a problem in adjustment to its environment. (2) This problem is formulated in language terms by the subject. (3) Learned and unlearned behavior is reinstated partly as a result of the external stimuli which are present, partly as a result of the subject's past history, and partly as a result of the facilitating and inhibiting influence of the language behavior. (4) The consequences of failure in any of the responses leads to a change in the language behavior of the subject. (5) If success finally comes, it will come in the form either of the arousal of an old form of response or of the formation of a new habit adequate to care for the problem. And (6) the subject may develop a language response capable of guiding the solution of all future problems of the same general character. The sequence of responses which constitutes thinking comes to an end when the behavior of the subject no longer concerns the problem which he has formulated. He may be engaged, e.g., in the solution of the foregoing "escape from the room" problem. If he succeeds in the solution the successful response terminates the thinking; and if he fails in the solution, the thinking terminates when the subject ceases to behave with reference to the problem.

Although thinking involves both the use of habits and the probable formation of new ones, it differs significantly from such a typical case of learning as is present in the acquisition of the maze habit. It also differs significantly from such behavior as the execution of a perfected typewriting habit.

Thinking is like maze-learning in that:	The following are necessary characteristics of thinking, but not of the other two types of behavior:
a) It involves an acquisition of substitutes.	*a*) A formulation of the problem by the organism.

b) It involves muscular and glandular responses to present stimuli.

c) It is a process of adjustment.

d) It is influenced by a drive, and ceases when the drive no longer controls the responses.

e) It is partially determined by the setting in which the response occurs.

f) It involves control through the self-stimulation of receptors.

b) The use and acquisition of non-automatic responses of the symbolic type.

Thinking is like typewriting in all of the foregoing respects, except that typewriting is more a use than an acquisition of substitute forms of response.

The conclusion is forced upon us that thought differs fundamentally from the general formation and use of habits in that it involves the exercise of language responses. The problem for solution is represented by these symbolic processes in the subject who is doing the thinking. Although the individual may have the problem set for him by another, yet unless it is incorporated into his own behavior system and unless it then modifies his behavior, this behavior is not thinking. This may be illustrated as follows: The knee-jerk in response to a blow on the patellar tendon and the pupillary response to an increase of light intensity are each methods of meeting problematic situations. Each serves to adapt the individual to his environment. There is, however, no evidence that either is controlled by the subject when he formulates in language terms the problem which the response solves. To say "The contraction of the pupil decreases the amount of light entering the eye" does not modify the pupillary reflex. All responses serve to solve some problem, and they solve these problems whether or not the subject has formulated the problem. Digestive processes have gone on for ages without verbal symbols existing for them. And the verbal symbols, i.e., the verbal statements of what digestion is for,

when once arrived at do not directly modify the process of digestion. As contrasted with these cases, thinking is a form of behavior which not only solves a problem, but which is controlled by the formulation of a problem by the subject in whom the thinking occurs. *Thinking is a sequence of responses directed toward the solution of a problem where the problem has been formulated by the subject's own language responses and where this formulation partially controls the sequence.* This thinking may be more or less successful in adapting the organism to its environment, just as protective reflexes may be more or less successful in ridding the organism of nocuous stimuli.

The Rôle of the Instruction-Stimulus.—We have seen that the two most characteristic aspects of thinking are language processes and the formulation of the problem by the subject. The essentials of language have been outlined previously, but the "formulation of the problem by the subject" is a factor yet to be discussed. When the subject is placed in a given experimental situation, such as a maze, a problem-box, or a behavior test of general ability, the stimuli contained in the situation serve to direct and limit the subject's behavior. Where verbal instruction stimuli can be given, these stimuli serve further to limit and direct the responses. Thus, if the subject is given the instruction stimulus "Write words that rhyme with hill," he writes. He does not talk. Moreover, most of the verbal responses which are reinstated do rhyme with hill. This influence of instructions can only be present where the instructions have been connected with definite forms of behavior by the past training of the subject. Clear evidence of this is seen in the futility of instructing a novice to confine his piano playing to certain symphonies of Beethoven or of instructing the average citizen to converse in Russian.

Instruction stimuli may be given to the subject by himself as well as by an experimenter. The subject may make the verbal response, "The problem to be solved is escape from the room." This verbal response may then control his subsequent behavior until the problem is solved or abandoned. The instruction stimuli are habit-

ual responses when they occur in the subject manifesting the behavior. When the instruction stimuli are given by an experimenter they arouse habitual responses in the subject. These responses are the subject's repetition and formulation of the problem to be solved. There is no sufficient reason for believing that instruction stimuli can occur in any other form than that of language.

The control of behavior sequences by the instruction stimulus gives to behavior that aspect called *purpose*. A man is said to work *in order to* secure food or to escape from a room. Wolves also are said to hunt *for* food. And so cases could be multiplied where the organism is said to regulate its behavior by an anticipated goal. There is no question that goals are attained by most responses, but the only way in which a goal can influence the preceding behavior is through the facilitating and inhibiting influence of instructions, which in their turn are reinstated language responses. When a man says, "I will now look for food," he is reinstating a language habit which can influence the behavior that is to follow in such a manner that food is more efficiently secured than if the language response had not been reinstated. This influence of language responses is not a unique phenomenon; it has its parallel in the control of behavior exercised by such visceral responses as stomach contractions. When stomach contractions begin in an animal, that animal becomes restless and, under natural conditions, begins the series of responses which terminates in securing food. When food has been eaten, the stimulation from the stomach changes, and the animal's behavior no longer concerns food-getting.

Although instruction stimuli are often repeated both by the subject and by the experimenter in order to confine the responses more closely to those bearing upon the problem, this is not always necessary. Once the subject has received his instructions, once he has been told, or once he tells himself, to escape from the maze or to write words that rhyme with hill, a persistent neural change is set up which in itself controls behavior. This persistent neural change is termed a *cortical* set, on the assumption that it occurs in

the cerebral cortex. Woodworth gives the following examples of "neural set" in infrahuman animals:

> A hunting dog following the trail furnishes another good example of a directive tendency. Give a bloodhound the scent of a particular man and he will follow that scent persistently, not turning aside to respond to stimuli that would otherwise influence him, nor even to follow the scent of another man. Evidently an inner neural adjustment has been set up in him predisposing him to respond to a certain stimulus and not to others.
>
> The homing of the carrier pigeon is a good instance of activity directed in part by an inner adjustment, since, when released at a distance from home, he is evidently "set" to get back home, and often persists and reaches home after a very long flight. Or, take the parallel case of the terns, birds which nest on a little island not far from Key West. Of ten birds taken from their nests and transported on shipboard out into the middle of the Gulf of Mexico and released 500 miles from home, eight reappeared at their nests after intervals varying from four to eight days. How they found their way over the open sea remains a mystery, but one thing is clear: they persisted in a certain line of activity until a certain end-result was reached, on which this line of activity ceased.[1]

Attention should be called to the fact that the terns were taken away from the nesting responses which were in progress. It is probable that the inner responses which served to direct the birds' behavior were partly connected with these interrupted nesting responses. Had the birds been chosen at some other period it is doubtful if they would have returned to the island. The behavior which Woodworth describes is not thinking. Although it reveals the control of behavior by an inner process, and although it is a problem-solving activity, the factor of control by symbolic processes is absent.

Habit Use and Habit Change.—In any process of behavior the responses which appear are either learned or unlearned. As a result of their appearance and of the additional exercise which they thus endure, many of these responses are modified, modified by

[1] R. S. Woodworth, *Psychology* (1921), p. 78.

training. Thus a use of old responses is always present, and the acquisition of new responses may be present. These processes of use and acquisition, while not peculiar to thinking, are also markedly present in that behavior. In the solution of a problem, such as that of the discs, the subject reinstates language responses which are the products of his previous training. As these responses, these hypotheses which he advances, are proved inadequate, they are changed for new ones. The result may well be that the subject emerges from the experiment with new language habits which may serve for the solution of later problems. To the extent that later habits are more quickly learned by virtue of the new language habits, to that extent is the relationship one of the transfer of training.

The logicians have termed the process of habit use, as it occurs in thinking, deduction. Induction is the term applied to habit change. Thus if I define man as a mammal with a white or yellow skin, this verbal behavior serves to control my thinking until it is proved inadequate. Whenever I meet a white or yellow-skinned mammal, I may respond by saying, "This is a man." Such a use of previously established habits is deduction. Through the use of this habit I encounter many stimuli, some of which will certainly arouse the response "This is a man" although he is neither white nor yellow. My verbal response must therefore undergo a change which modifies the definition of man. This process of the formation of definitions, of the acquisition of habits, is induction. Induction is essentially a process of discovery, whereas deduction is the utilization of that which is already discovered, or established. Both processes are always present in varying degrees in each instance of thinking.

Efficient Thinking.—Thinking is efficient to the extent that it adjusts the organism to its environment with the least expenditure of effort and in the most efficient way. If two men working in the same cultural period both devise electric telegraphs, we should rate that thinking the better which resulted in the better apparatus produced in the lesser time. By the better apparatus we should understand the one which solves the problem of distance communication

with the lesser error and which can be constructed without undue difficulty.

Efficient thinking is aided by a relative independence of that behavior and emotion. The neural processes underlying emotional behavior have *the right of way* (see p. 180) to such an extent that other neural processes which represent the individual's accumulated training have little opportunity to determine his present mode of response. An acquaintance with scientific method, which we are shortly to describe, is also a great safeguard against maladjusted behavior. Efficient thinking is also aided by extensive and intensive training in the fields in which the thinking is to occur. It is difficult e.g., to do efficient work in electricity unless one has available the fundamental habits represented in the past discoveries of other students. But even with equal training, two men may differ greatly in the skill and aptness with which the old training is utilized in the solution of new problems. Perhaps this difference is one of general or special ability. It is, in any event, a difference in the ability to discriminate the essential aspects of the problem to be solved, plus a difference in ability to bring the most relevant past training to bear upon the present problem.

There is no better field for the demonstration of the methods of efficient thinking than that offered by the study of cause and effect relationships in the field of science. The general hypothesis under which such work proceeds is that *although a given effect may have several possible causes, any one of which may be sufficient to cause it, no effect can occur in the absence of a cause.* The most important methods used in the determination of causal relationships have been formulated by J. S. Mill, an English logician, as follows:

1. The method of agreement. *If two or more instances of the phenomenon under investigation have only one circumstance in common, the circumstance in which alone all the instances agree is the cause (or effect) of the given phenomenon.*

2. The method of difference. *If an instance in which the phenomenon under investigation occurs, and an instance in which it does not occur, have every circumstance in common save one, that*

one occurring only in the former; the circumstance in which alone the two instances differ is the effect or the cause, or an indispensable part of the cause, of the phenomenon.

3. The method of concomitant variation. *Whatever phenomenon varies in any manner whenever another phenomenon varies in some particular manner, is either a cause or an effect of that phenomenon, or is connected with it through some fact of causation.*

These methods can be stated in symbols as follows:

Method of Agreement	Method of Difference	Method of Concomitant Variation	
Abc N_1	Abcde NL	AB 3	CD 1 or 3
Dec N_2	Abcd **L**	AB 2	CD 2
Fgc N_3		AB 1	CD 3 or 1

Abc, Dec, Fgc represent the antecedent conditions of three instances, N_1, N_2, N_3, of the same phenomenon, e.g., instances of the presence of behavior in terms of the illustration which we are about to give in the following paragraph. Since only *c* is present constantly, it probably is the cause of *N*, or a part of the cause, or else it is caused by the same factor that causes *N*. In the method of difference, *Abcde* and *Abcd* represent two antecedent conditions of the phenomena *NL* and *L*, respectively. Since where *e* is absent, *N* is also absent, the same conclusions that we made before concerning the causal relationships between *c* and *N* can now be drawn concerning *e* and *N*. In the method of concomitant variations, *AB* 3-*CD* 1, *AB* 2-*CD* 2, etc., occur in the same object. Inasmuch as *AB* and *CD* vary together, *AB* growing smaller as *CD* grows larger, we may conclude either that one is the cause of the other or that both have a common cause. *AB* may be the behavior test score, and *CD*, the scholastic success of an individual; *AB* may be the complexity of the nervous system, and *CD*, the complexity of behavior; or *AB* may be temperature changes, and *CD*, changes in length of the substance.

Let us further illustrate these methods. Suppose that our problem is to solve the relationship between the nervous system and behavior. By the method of agreement we find that all animals possessing a nervous system manifest behavior, although they differ in

all other ways. We may then select two animals similar in all essential respects except that one normally has no nervous system while the other has (this is the method of difference). Both of the animals manifest behavior. In order to push our study farther with this method, two animals having nervous systems and who are otherwise alike are chosen. One of these is operated upon and a portion of the nervous system is removed. When the behavior of the two subjects is now examined, differences are found. Finally, working by the method of concomitant variations, we rank a great variety of animals from lowest to highest on the basis of the complexity and variability of behavior, and then re-rank the same individuals on the basis of complexity of the nervous system. A comparison of the two rankings reveals a high positive correlation. From these experiments—and *experiments are only rigorously controlled instances of thinking behavior*—we reach the solution of our problem. This solution can be stated as follows: Behavior may occur in animals lacking a nervous system; but where the nervous system is present it controls some of the organism's behavior. Moreover, a highly complex and variable behavior is made possible by a highly complex nervous system.

Many possibilities of erroneous conclusions occur with the use of these methods, possibilities against which the thinker must be on his guard. Sometimes multiple causes are at work in place of the one which is being analyzed. Sometimes the two factors which seem to be cause and effect are really two effects of a common cause. Sometimes factors undiscriminated by the observer enter into an experiment to confuse the results; and frequently more than one factor, in the method of difference, is varied at one time. The only remedy for these sources of error lies in repeated experimentation and in increased care in the control of conditions.

Conclusion.—We began our discussion of human behavior with a discussion of the methods of investigation used in the science. Here, at the close of the book, we see that these methods are partly methods of behavior in the scientist and partly the experimental settings which control that behavior. Thinking, we have

said, is a sequence of behavior controlled by the language, symbolic, processes of the subject doing the thinking. The scientific methods of thinking just described represent the most efficient and therefore the most adaptive forms of this response. The general instruction stimulus under which scientific thinking occurs is this: *All phenomena have causes which can be discovered sooner or later by scientific thinking behavior.* Scientific thinking and the control of behavior by the foregoing instruction stimulus are the characteristics which we designated (p. 35) as the distinguishing mark of present Western European culture, as previous cultures have been marked by the use of polished stone, iron, or bronze. For unknown ages man has manifested thinking behavior, but only in relatively recent years has he set out to regulate his individual and social problems by *scientific* thinking. Man has, after long years of struggle, formed one more hypothesis with which to regulate his behavior. This hypothesis of the value of scientific thinking gives every evidence of proving the most useful hypothesis of all, since it enables the individual more adequately to use the cause and effect relationships present in his environment. Because infrahuman animals lack language processes in any significant degree, they have never formulated cause and effect relationships, and hence have been unable to regulate their behavior with reference to this aspect of the world. Although man has long had well-developed language processes, he has only recently succeeded in devising and securing the widespread social adoption of proper methods for formulating cause and effect relationships. This late success has resulted in loading his behavior *repertoire* with a multitude of customs replete with maladaptations in general and superstition in particular. Even yet large segments of individual and social behavior have not been successfully brought under the control of scientific thinking. However, the hypothesis of the universal validity of the method has been formulated, and where it has been applied in the control of behavior it has yielded such excellent results that its future wider application cannot be in doubt. In these yet unregulated fields, as elsewhere, thinking behavior, efficient thinking

behavior, tends to be inhibited by emotional reactions, the prejudices, hates and fears of men. Through their prepotency these emotional reactions break in upon and disarrange orderly sequences of response.

REFERENCES

ANGELL, N. *The Public Mind* (New York, 1927).

CREIGHTON, J. E. *An Introductory Logic* (New York, 1909).

DE LAGUNA, G. A. *Speech: Its Function and Development* (New Haven, 1927).

DEWEY, J. *How We Think* (Boston, 1910).

HUNTER, W. S. "The Symbolic Process," *Psych. Rev.*, XXXI (1924), 478–97.

LIPPMANN, O., AND BOGEN, H. *Naive Physik* (Leipzig, 1923).

WATSON, J. B. "Is Thinking Merely the Action of Language Mechanisms?" *British Jour. Psych.*, XI (1920), 87–104.

———. *Behaviorism* (New York, 1924).

INDEXES

AUTHOR INDEX

SUBJECT INDEX

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